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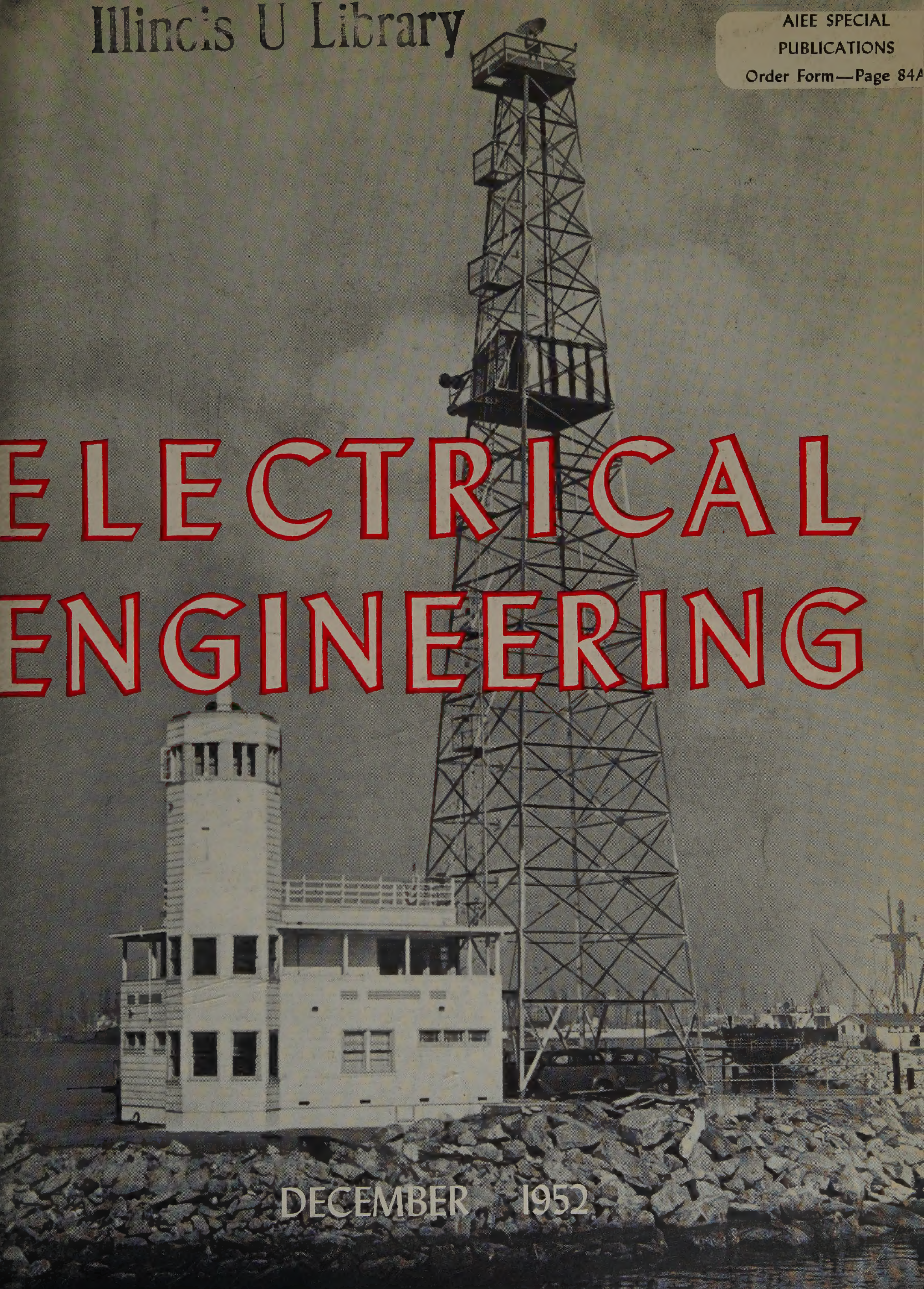
ELECTRICAL ENGINEERING



DECEMBER 1952

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ELECTRICAL ENGINEERING

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The Cover: Radar site at Long Beach, Calif., harbor. The antenna is mounted on top of a 125-foot-high oil derrick with the transceiver located in the shack farther down the derrick. The indicator is mounted in the pilothouse at the base. This and other shore-based radar installations for the surveillance of marine traffic are described in the article on pages 1072–7.

Charles S. Rich, *Editor*
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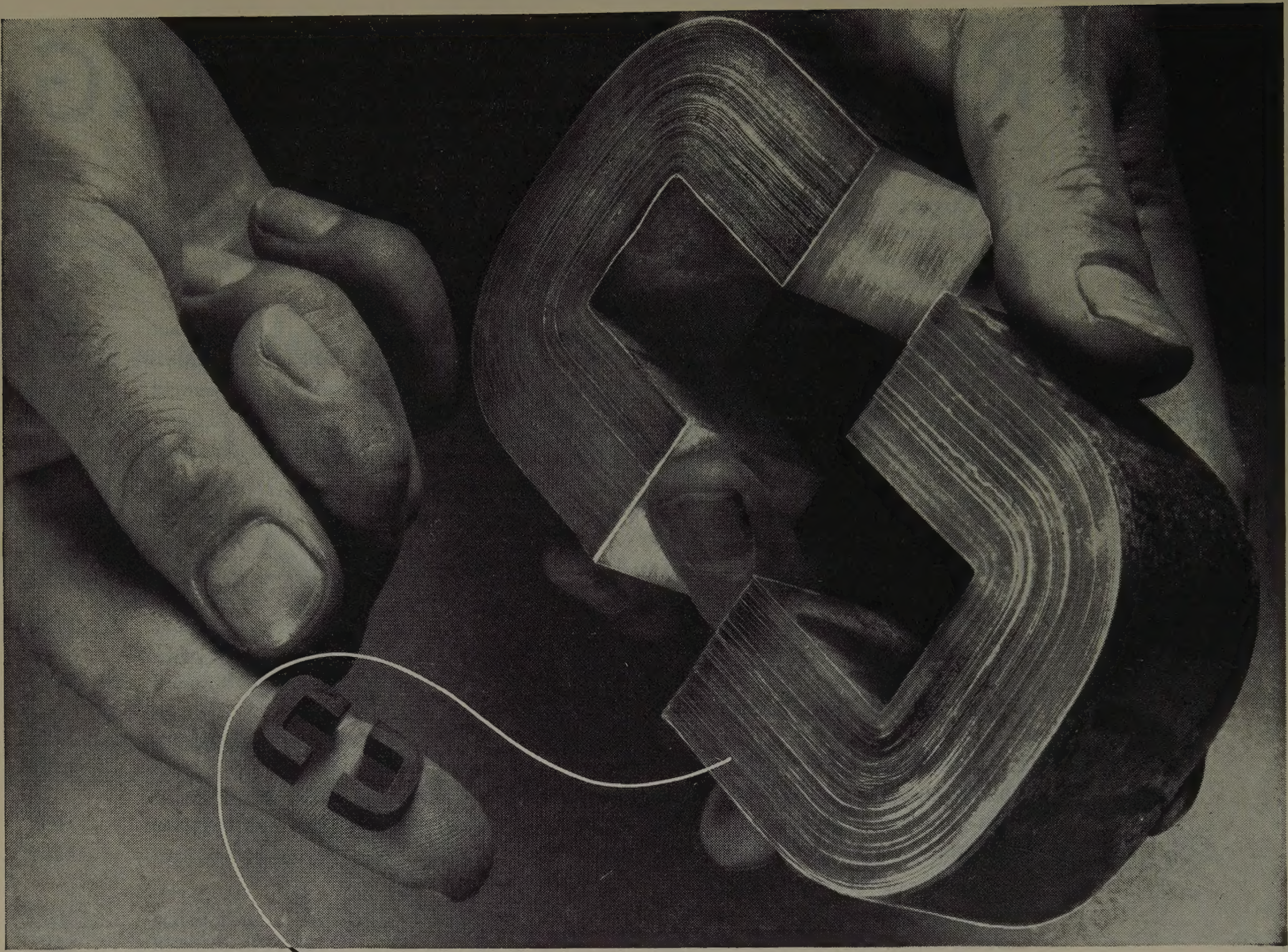

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HIGHLIGHTS........

Electric Power in Industry. About a 45 per cent increase in industrial productivity must be achieved in the next 10 years, according to the author, to maintain a balanced expanding economy. It is felt that the most important factor will be the more intensive application of new technological developments in the form of new devices, new materials, and new processes; all of these will increase the use of power, of course (*pages 1061–7*).

Feedback System Engineering. As considered in this article, feedback system engineering is "the co-ordinated creative synthesis of the process, the plant, and the instruments." Although it dates back to about the time of the invention of the flyball governor, it was not until World War II that the concept began to play an important part in the practice of design and development (*pages 1067–71*).

Equipment for Harbor Radar. Shore-based to assist in harbor piloting should include high-resolution radar, good instantaneous 2-way voice communication between the shore-based radar operator and the man at the bridge of the vessel, and the ability to identify the particular vessel in question by the radar operator. Specific harbor installations are discussed briefly (*pages 1072–7*).

Typical Block Diagrams for a Transistor Digital Computer. Just as vacuum tubes have been replacing relays in computer design within the past few years, it now seems as though transistors were going to replace tubes. In this study, block diagrams are given of switches, memory units, arithmetic units, and other basic computer components (*pages 1103–08*).

News Index

Management Looks Ahead in Electric Power Industry. The president of The Detroit Edison Company considers the part that engineers play in management. Because a strike at his company necessitated his presence in Detroit, Mr. Cisler's address was presented via television to the Middle Eastern District Meeting in Toledo (*pages 1079–81*).

Professional Engineering in California. What is professional engineering? Who has the right to be a professional engineer? The author, a representative on the California Board of Registration for Professional Engineers, discusses registration in his state (*pages 1082–7*).

Completely Self-Protected Banking Transformers in Secondary Banks. Data are presented in support of the view that this type of secondary banking offers a practical solution to many of the problems present with radial systems. The replacement of fuses with low-voltage circuit breakers is considered to eliminate the earlier disadvantages (*pages 1109–11*).

Weathering and Crack Resistance of Black Polyethylene. A light absorption test was developed which correlates very well with accelerated weathering and more accurately predicts the weathering life of a carbon black polyethylene compound. The addition of small amounts of pigments, fillers, or antioxidants do not adversely affect cracking characteristics, in fact some appear to improve cracking characteristics (*pages 1113–17*).

Working Definitions for Color Television. This glossary of terms was prepared by Panel 19 of the National Television System Committee and approved by the committee. They are tentative, as further progress in the art will cause changes in the usage of the terms. However, it is felt to be to the best interest of color television to make them available at this time (*pages 1120–2*).

Welding in the Electrical Industry. Welding is traced from its use by the ancients to its present prominence and future potentialities. Materials, processes, applications are covered in this summary of welding's role in the electrical industry (*pages 1095–1100*).

Electric Home Appliances. Electric appliances now perform an increasing number of duties in the home and play an important part in our lives. The growth and development of these appliances is described (*pages 1087–90*).

Bimonthly Publications

The new bimonthly publications, *Communications and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, superseding the AIEE *Proceedings*, contain the formally reviewed and approved numbered papers (exclusive of ACO's) presented at General and District Meetings. The publications are on an annual subscription basis. In consideration of payment of dues, members may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Modern Flight Simulators. A single piece of equipment may use over 1,000 vacuum tubes and consume 35 kw of power. The growth, savings effected by its use, and design are stressed (*pages 1124–9*).

Current Field Practices in Electrical Tests on Dielectrics. This report briefly discusses the results of a questionnaire submitted to 183 utilities and service companies, representing 241 operating systems in the United States and Canada whose combined generating capacity totalled over 65 million kw (*pages 1132–5*).

Management of Engineering Work. Management is the administration of a business enterprise through leadership by planning, organizing, measuring, and co-ordinating. The application of these principles to engineering work is discussed (*pages 1091–5*).

A 10-Stage Cold-Cathode Stepping Tube. A multielectrode gas tube of stable characteristics is described which has the property of forwarding a discharge from one set of cathodes to the next to a common anode. The operating characteristics, available output voltage and power, and other data are described (*pages 1136–39*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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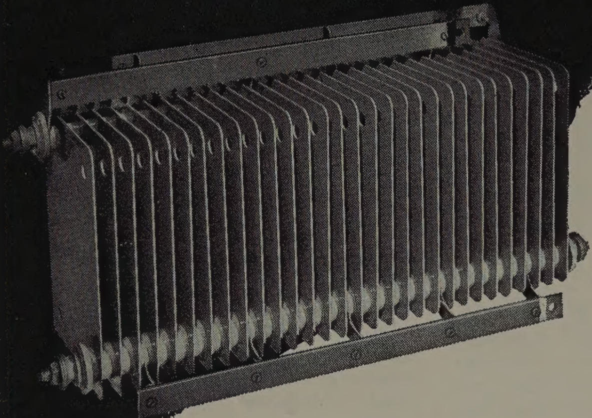
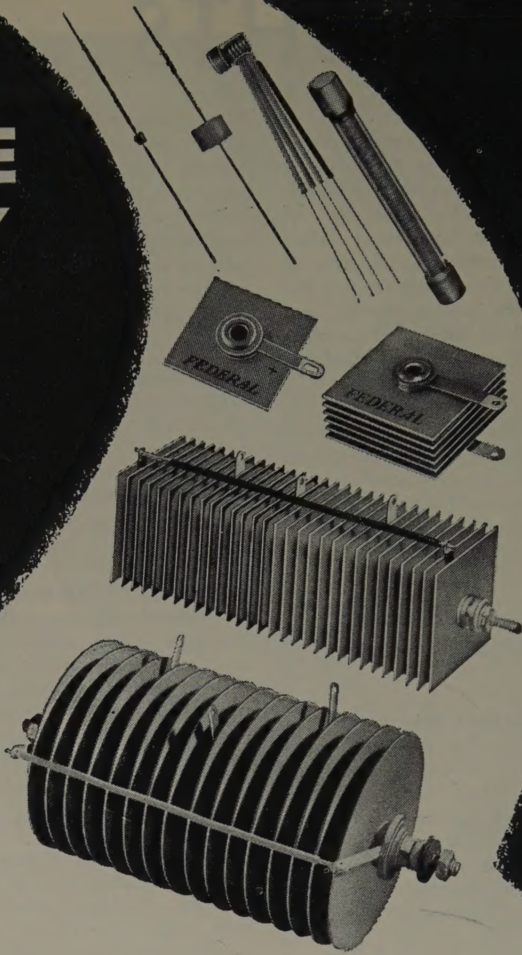
SUBMINIATURE to HEAVY DUTY
From
MILLIWATTS to KILOWATTS





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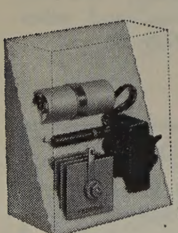

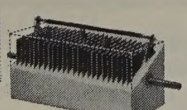

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Electric Power in Industry

F. R. BENEDICT
MEMBER AIEE

The four important factors—the production workers, production machinery, production processes, and materials—controlling the rate of industrial progress are discussed and evaluated. New developments are included along with ideas concerning future trends.

MOMENTOUS AS the developments of the past 100 years have been, the future for electric power in industry is so bright that it is time to take stock and make plans to continue to forge ahead. There are four important factors that will govern the rate of progress. The first is production workers; the second, production machinery; the third, production processes; and the fourth, materials. Each factor is influential in economic growth and, therefore, must have increasing engineering attention.

THE PRODUCTION PROBLEM

TO MAINTAIN A balanced expanding economy, industrial productivity must increase about 45 per cent in the next 10 years. See Figure 1. Industry becomes great only when it is faced with a great challenge. The question is: "What methods does industry have available that will make it possible to meet this challenge?"

One is to operate production machinery for longer periods in a given day. This has definite limitations as there is not and will not be a labor force sufficient to man our productive facilities fully on either a full 2- or 3-shift basis. What gain results is largely temporary.

A second approach that has been widely studied is to speed up the worker. There is a strong social trend away from any such move. In the aggregate, little if any can be hoped for in the way of increasing production by this device.

A third approach has been toward the improvement of personal working efficiency. The application of labor-saving machinery is receiving increased attention throughout all industry. Undoubtedly, some further gains can be made by installing more fully automatic machines and giving high priority to product planning to reduce labor content.

A fourth approach is that of improved management and organization. Management must organize to make every bit of production effort count. Intensive attention must be given to the reduction of labor content per unit of production, but even so, there will be a shortage of labor. One procedure is to institute cost-reduction programs utilizing the latest manufacturing techniques, materials, methods, and processes. The activities of engineers, already in extremely short supply, must be organized and planned so that maximum benefit will be obtained from their education and experience. There must be continuous effort on simplified designs to reduce engineering content. On the whole, however, only a modest increase in production can be expected from this approach. See Figure 2.

What then will be the critical factor in meeting the production challenge? It is felt that the increased production required can be achieved in only one way: by the continued but more intensive application of "new technological development" throughout all industry.

The most important problem is considered to be that of effecting complete co-ordination of product development with development of production facilities and tools to manufacture the product. Where a design is going through a minor change, this may not be too important, but where a new product is being engineered, production and engineering must effect a design reconciliation that will allow economical manufacture of the product. For many products, such a reconciliation will mean full-scale pilot plants to prove the design for manufacture.

A second important problem is management's attitude toward existing low-profit manufacturing facilities. If production facilities cannot be made sufficiently profitable, management has only two choices: first, to live with the situation or, second, to "plow the facility under" and start anew. With pilot plants an accepted preproduction tool in many industries, management need not take great risks, but it must evaluate and decide.

A third problem in the application of new technological development is that of assigning research, development, and engineering personnel to the incorporation of new technological development into the product or production process. If a development has attractive possibilities it must be investigated and evaluated for eventual incorporation into the product or process if it is worth while.

A fourth problem which will have to be studied more fully in the near future is product life. American industry has a world-wide reputation for building quality products. Perhaps they are sometimes too good, in the sense that they still have a high percentage of their life left when they are obsolete. It might be advantageous from a long-range viewpoint to reduce the active life of some products so that they could be built at much lower cost.

TECHNOLOGICAL DEVELOPMENT

THE TERM "technological development" has been used repeatedly in discussing the attainment of increased

Revised text of paper **52-259**, "Electric Power in Industry," recommended by the AIEE Industry Division Committee and approved by the AIEE Technical Operations Committee for presentation at the Centennial of Engineering, Chicago, Ill., September 10–12, 1952. Not scheduled for publication in AIEE *Transactions*.

F. R. Benedict is with Westinghouse Electric Corporation, Pittsburgh, Pa.

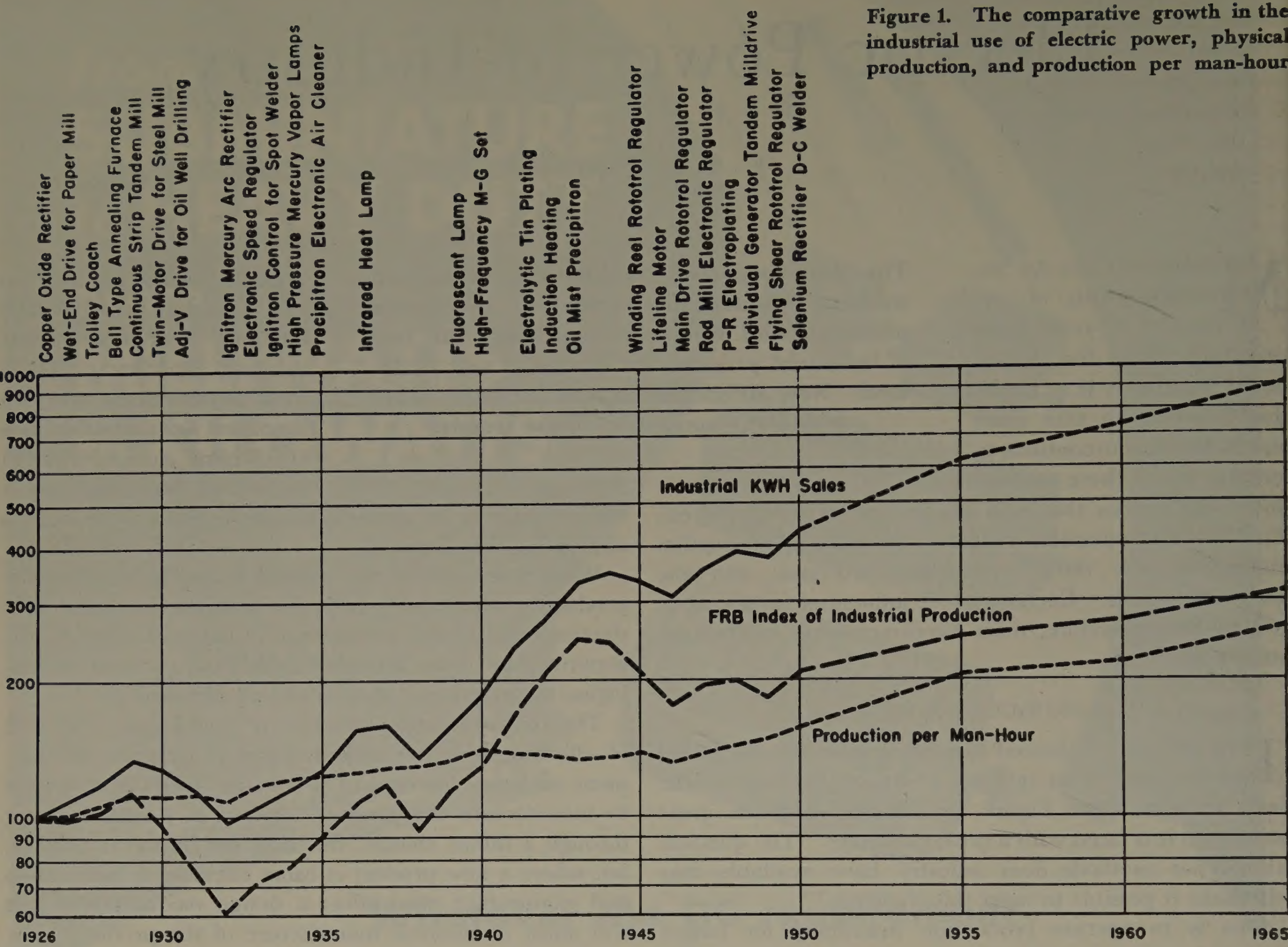


Figure 1. The comparative growth in the industrial use of electric power, physical production, and production per man-hour

production. The scope of this term takes in such a wide variety of technical development fields that it will be possible to discuss here only a few that are of high importance to the application of electric power in industry.

MOTORS

The work horses of industry are a-c and d-c motors. With the designs already reworked many times, are further major design improvements possible or practical, and along what lines can these improvements be made?

Motors have been more and more completely enclosed. Not only is this apparent in the general-purpose motor but also for motors suitable for special applications—such as explosionproof construction for hazardous atmospheres, the lintfree (textile) motor, the chemical motor, and the sanitary food-industry motor. The trend seems to be toward a single, completely enclosed, self-cooled motor that can be used for general applications and can further be used for most of those applications now requiring special enclosures.

Counter to this trend is the demand to reduce the physical size of motors. Successful development and application of silicone insulations will permit a further reduction in size if temperatures are allowed to rise. However, "hot" motors have disadvantages from the standpoint of the bearings and personal hazard. Development of a stable, high-temperature bearing lubricant would provide the needed incentive to conclude such a development. Then too, improved electrical sheet steel would enable the designer to improve power factor, torque, and efficiency, the critical characteristics that are affected by reduction in motor size.

Motors are the sinews of industry and will be depended upon in the future even more than today as expanding automaticity sets new requirements for plant operation. The automatic plant for repetitive or high-volume products is not far in the future, in fact it could be built today from known components. One characteristic such a plant must have is continuity of power. Drives for automatic plants will require motors with windings of extremely high reliability, in essence, predictable life. Predictable life windings are not out of the realm of possibility with existing known materials. Bearings too will require redesign to provide predictable life. Special sleeve and ball bearings with good lubricating and sealing systems may provide the solution.

The need for a low-cost drive, adjustable over a wide speed range, up to a ratio of several hundred to one and subject to precise control and regulation, is still a pressing and unfulfilled need. The lack of such a drive explains the long-continued demand for and use of the d-c motor. While the commutator has been regarded with distrust as a wide-speed control device, the fact remains that it is still the cheapest and best. The future's d-c single-motor

drive probably will have the rectifier and control, possibly the magnetic amplifier type, built directly into the machine frame so that each unit will be self-contained requiring only a-c power for operation. Many of the disadvantages of d-c single-motor drives would thereby be eliminated, and they would find much wider use in our predominantly a-c equipped plants.

CONTROL

THE MANY DEVICES used in machine and process control took their essential form some decades ago. Improvement in detail has been important but unspectacular. Originally, the control engineer had only to provide a means by which a motor could be started and stopped. Multiple drives were introduced that required co-ordination of their actions. Complicated duty cycles appeared. Speeds of machines were increased enormously. Precision operation became essential. It fell to the control engineer to create control systems that would reduce or completely eliminate the need for operator action. Some components were available and others were developed, but outstanding success has been achieved in developing control systems that meet the needs of the industry.

Better motor controls are needed. While the electron tube has been one of the important building blocks of control, tubes with vastly increased life and rating are needed urgently. Few tubes have a life over 10,000 hours. Better tubes, with longer life, and more uniform characteristics, will probably come. The trend toward reduction in tube size coupled with improvement in performance will be of great help to the control engineer.

An important function in control is that of rectification and amplification. Semiconductors are already well established in the control field in the form of copper oxide, selenium, and germanium rectifiers. Fundamental research on exceedingly pure materials in single-crystal form holds great promise for increasing current capacity with improved rectifying characteristics. The inability of our present semiconductor rectifiers, copper oxide, selenium, and germanium, to operate satisfactorily at elevated temperatures is spurring research on new materials. Announced results of investigations on the properties of pure silicon indicate the first successful attempt to solve long-standing temperature-barrier problems. There is a real possibility of increasing the operating temperature to as high as 200 degrees centigrade. There is also indication that the rectification characteristic may be improved at least one magnitude and possibly two. This development gives the control engineer new hope, for with such a rectifier, he will be able to make controls smaller, lighter in weight, and vastly improved in performance.

The simple rectifier does not permit the control that the grid provides in an electronic tube. However, the recently developed transistor, a semiconductor, does permit tube-type control. New developments on germanium, silicon, and other semiconductors hold real promise that the transistor will be able to handle higher power, both increased current and increased voltage, in the near future. It is quite unlikely that these devices will supplant tubes completely. Rather, this development will encourage tube development and will certainly result in higher capacity, longer lived, and more rugged tubes.

To perform control functions, the control engineer must use devices for closing and opening circuits under power conditions. The end of present contactors with open arcs can be anticipated. Some way to enclose the arc and snuff it out in a high dielectric gas or possibly a vacuum will be found. Grid-controlled ignitron tubes that perform the circuit making and breaking function are widely used in spot and seam welding, and small electronic motor controls. Here they perform a specific make-and-break function where contactors cannot operate rapidly enough. Grid-controlled tubes can be applied as contactors, but they are considerably more complicated and expensive than contactors.

It is believed that the long-range objective will be a drive unlike any in today's catalogues. It will give wide speed variation, through either a frequency changer or rectifier built into the frame. The motor will be failure-proof with a switch or starter built into the terminal box. It will have built-in thermal and overload protection. It will require only a foundation, electric connection, and a shaft connection. It will be an integrated drive, compact, foolproof, self-protecting, and maintenance-free. The time is coming when a process shutdown, with its enormous cost, must not be chargeable to the motor and its control.

REGULATORS

ELECTRIC CONTROL has always been characterized by the ease with which small quantities, such as slight changes in current or in voltage, can be made to control the action of large devices such as motors or generators. In the successful operation of any regulating means, it is necessary that the apparatus be able to compare the actual value of the quantity being controlled with the standard or calibration value desired. If there is any difference between the actual and desired quantities, the regulating device must supply power of the correct magnitude and direction to eliminate the difference.

One of the brightest chapters in control history opened when engineers began to use a rotating machine to control rotary machines. Essentially, the rotating regulator is

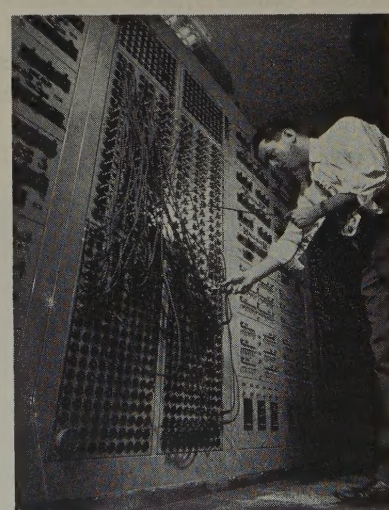


Figure 2. Engineers need new and advanced analytical tools. On the analogue computer shown here almost any mechanical, electrical, thermal, or hydraulic situation can be duplicated and fully analyzed

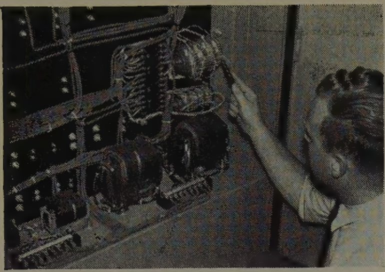


Figure 3. A magnetic amplifier for a steel mill regulator. Small, rugged, and reliable, it takes the place of rotating equipment many times its size

an a-c driven d-c generator equipped with additional control fields. These fields are supplied with a current representative of the quantity to be regulated. Variations in this current are amplified in the regulator output, theoretically a million times if necessary. The output is then fed to the controlling device to provide the control function. While high theoretical amplifications are possible, a practical limit is set by the difficulty of designing and building the machines. The simpler, more easily built magnetic amplifier will undoubtedly displace the rotating regulator for many applications.

The magnetic amplifier has been known and used for years. Basically, the device is used to secure amplification through the use of saturable reactors either alone or in combination with other circuit elements. The first applications involved the use of simple saturable reactors in which the reactor impedance was varied by circulating direct current through a separate winding and thereby saturating the core material. Relatively large amounts of a-c power could be controlled by small amounts of d-c power. The magnitude of power amplification obtained in this way, however, was not exceptional.

The first major advance came with the discovery of the principle of self-saturation. By using saturable reactors in combination with rectifier elements and allowing only unidirectional current to flow in the output winding, it no longer became necessary for the control excitation to counteract the magnetomotive force established by the output current. The control excitation could be fully used for saturating the core material.

With these developments much larger power amplifications could be obtained, but the potentialities of the device were not fully realized until the development of automatic feedback control systems. These systems required amplifying devices and the advantages of the magnetic amplifier, as compared with rotating and electronic amplifiers, soon became apparent. By providing a multiplicity of control windings, signals can be added or subtracted in the same manner as is presently done with the rotating regulator.

The magnetic amplifier has tremendous potentiality for a great future. It will enable controls to be built smaller and lighter. As it is a static, rugged device, it can be designed to withstand high shock and will be able to supplant tubes in many critical applications. Its simplicity and stability will encourage less complicated, more easily maintained control.

In the steel industry, one of the most critical applications is the regulating equipment used in tandem cold reduction mills. Modern drives include individual d-c generators for each stand motor. A magnetic-amplifier voltage regulator for this service has been developed and rigorously tested with full-sized rotating equipment. The amplifier controls the excitation of a 3,600-kw generator supplying power to a 4,000-horsepower motor. Under simulated operating conditions, over-all performance was outstanding. The speed of response was 1/10 of a second for complete correction of a simulated load change. Both 60- and 400-cycle amplifiers were built to test their relative performance. For this critical application, the 400-cycle system with its smaller cores and better response time is being adopted; for less stringent applications, the 60-cycle system is satisfactory. Both reliability and response time are equally important and both needs are well filled with this device. See Figure 3.

Other industries stand to profit as well. The next few years will bring widespread use of this new and versatile tool. The popularity of magnetic amplifiers is growing for one reason alone, their ability to do economically the job assigned without special attention.

PROCESSING

As STATED EARLIER, the treasured and incomparable American standard of living is based on the steadily rising productivity of its workers. The development program is without end. Developments that enable workers to turn out more materials or goods in a given time, or better goods with less effort, show up constantly and can be expected to continue. But almost always, it is at the expense of more British thermal units or kilowatt-hours. Let me cite an example at random. The output speed of one of the largest tin-plate mills was recently raised from 1,500 to 3,125 feet per minute with corresponding increase in productivity. To get this doubled output, the horsepower of the driving motors was almost tripled, being increased from 3,900 to 10,500 horsepower.

The food-processing industry, the packaging experts, and the electronics engineer may co-operate to make tomorrow's food preparation very different from that of today's. Dielectric cooking has met thus far with little success. Possibly that is because it has been used simply as a replacement for present stoves. Its success may lie in changed food-processing methods designed to use dielectric heat. Tomorrow, perhaps the housewife, instead of buying a steak which is simply a slice from a side of beef, will purchase a homogenous piece of meat, deboned, and minus fat, all electronically tenderized, and packaged and frozen in individual serving containers labeled with directions as to settings of frequency and time for the home dielectric cooker. The prospect is for major changes in

Figure 4. A 32 - feet - per-minute conveyor distributes motor frames and other parts to winding positions. Workers slide stators on and off conveyor

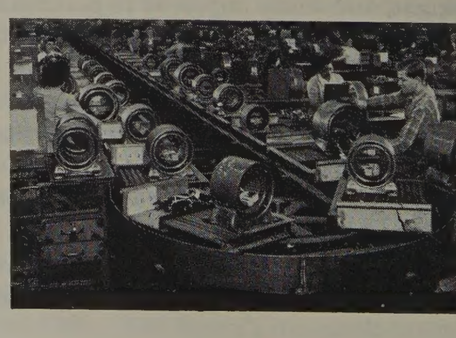
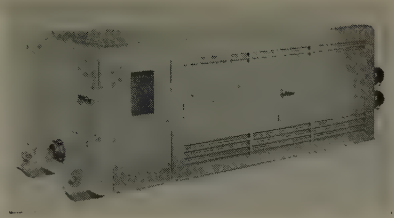


Figure 5. New ventilated dry-type mine power center. Compact and highly versatile, such equipment will reduce the problems of mine mechanization



food packaging, fruits, vegetables, meats, even cereals, trends that may take into account electronic processing and sterilization at the factory and electronic thawing or cooking at the home table. The days of "long hours" in a kitchen may disappear.

MACHINE TOOLS

Machine-tool techniques change as materials change, but in every step in production the human element is gradually being removed. Machines are operating at higher speeds with more horsepower input. Automatic loading, automatic operation, and automatic unloading is rapidly increasing and is becoming standard practice in the automobile manufacturing industry. The new technique is to set up fully automatic machines in series and automatically pass the material from machine to machine until it emerges completely finished. Quality will be improved by elimination of the human element, less plant space will be required, safety will be improved, waste and spoilage will be less, and production will be increased.

MATERIALS HANDLING

Automatic processing equipment requires, for its full utilization, automatic materials handling. In this automatic process nearly every human body action is simulated. Machines start, stop, push, pull, twist, rotate, grasp, release, lift, and carry. They do these things more positively than any human and they operate at high speed. For every new material or process, materials handling and the process must be designed together with complete and positive integration. The future production picture will depend on how production lines produce and every effort should be made to obtain the benefits of well-planned materials handling. See Figure 4.

Other industries have great interest in materials handling too. The construction industry has long used belt conveyors to handle earth, sand, and gravel over distances up to 10 miles. Our long-range planners in these fields think that distances can be extended economically to 50, 100, and 200 miles. Actually, a 135-mile conveyor from Lorain to East Liverpool, Ohio, has been carried through the advanced engineering stage. This conveyor would be two-way, carrying materials in both directions simultaneously. It would be enclosed for year-round operation. Its cost would be high, but its proponents claim for it the ability to handle very large amounts of material economically.

Coal mining, our basic fuel industry, is one that is undergoing rapid mechanization. Intensive development has produced coal-mining machines that can produce coal in such quantities at the mine face that existing coal haulage systems are literally swamped—with a resultant loss in efficiency in coal mining operations. New coal-handling systems will solve this problem and they may take various forms; higher speed, higher capacity mine locomotives; belt conveyors; improved coal loaders; improved shuttle and transfer cars, all have their place in this mechanization. Coal will remain our key fuel for a considerable period of time and current developments assure an adequate supply for the future. The kilowatt-hour per ton is rising and it will continue to rise for a long time. See Figure 5.

MATERIALS JOINING

Our whole world is made up of things fastened together. Early in the century, it was the order of the day to bolt or rivet metals together. With the development of d-c welding our construction practices changed markedly and welding rod, deposited in the heat of an arc, largely supplanted the rivet in metal joining. Electric power use rose precipitously, and it has not leveled off yet. The term "fabricate" became widely associated with parts of products made by welding metal pieces together. As it has always been difficult to obtain large sound castings, fabrication has become the preferred method for making those parts, such as water-wheel-generator spiders that must be sound for safety reasons. Large simple parts such as shafts and high-speed turbine-generator rotors are always made from forgings to assure soundness. See Figure 6.

Production pressure will require engineers to consider more carefully their designs requiring joining of parts. Many engineers feel that fabrication has been taken too far into design and that casting of complicated structural components should be reconsidered for economy. New casting techniques, such as the *C* process which uses a thin baked resin-sand shell, has made possible sound castings of low cross section with excellent surface finish and high dimensional accuracy.

Seam and spot welding has been developed to a high state of perfection and, as nearly every common construction metal may now be successfully welded, it should remain a preferred process. In arc welding, the Heliarc method has made it possible to weld nearly all of the hard-to-weld materials. It is particularly useful on stainless-steel alloys. Automatic welding by the shielded-arc process is in regular use in industry and has been a big factor in making the all-steel-frame motor possible.

CHEMICAL PROCESSES

The continued existence of the United States as a nation, will depend critically upon the chemical

Figure 6. A giant 79-ton spider being welded. It is the inner framework for the rotor of one of the 108,000-kw water-wheel generators for the Grand Coulee Dam power plant. 31 feet in diameter, the rotor will weigh 542 tons, and rotate at 120 rpm

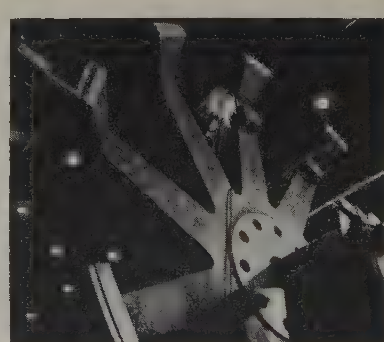


Figure 7. Melting the charge in a 10,000-kva 3-phase Heroult-type electric arc furnace. The electrodes are positioned with respect to the furnace charge by an automatic rotating arc furnace regulator

industry. Phosphorous, nitrogen, and potassium normally are depleted from the soil by food growing more rapidly than they can be returned by rotting vegetation. The difference must be made up through distribution of manufactured fertilizers. About one-half of the sulphur is used in the form of sulphuric acid for the manufacture of phosphate fertilizer. Sulphuric acid, a chemical basic to most other chemical industries, takes nearly all of the other half of the available supply. Sulphur is in short supply and our available resources do not indicate an early solution. Phosphorous production for detergents and industrial cleaning compounds will increase from the 180,000 tons used in 1951 to 260,000 tons by 1954. The growing shortage of sulphur and the rising demand for fertilizer suggest that the electric-furnace method for making fertilizers may grow rapidly in importance. Electric power use in this industry is about 4,000 kilowatt-hours per ton and 1954 energy consumption will be over one billion kilowatt-hours. It ranks second only to aluminum in power use in the whole chemical industry. Production must increase so the trend in power use in the future will be at an ever-increasing rate. See Figure 7.

The greatest power user in the chemical industries is aluminum. Production, which in 1951 was 800,000 tons, will be increased to 1,500,000 tons by 1954. Power consumption in 1954 will then be at a rate greater than 30 billion kilowatt-hours per year for reduction only. This will be about 6 per cent of the country's total energy output.

Many products are manufactured from low cost, readily obtainable materials such as hot- or cold-rolled steel and then electroplated to provide corrosion resistance, and attractive long-life surface finish or a surface that will resist wear. The electroplaters' problem has always been to obtain a smooth clean base finish on the article to be plated, so the plated surface will be smooth and free from imperfections. This has been done in the past by buffing operations which are very expensive and time consuming. Periodic reverse electroplating, with and without solution additives, has already made possible lighter plates with smoother finish and less porosity, providing higher corrosion resistance and better surface finish.

It has always been the electroplaters' goal to be able to lay down a thin perfect plate of any desirable metal on any base metal. Just think what it would mean if it were possible to plate common steel with zirconium, titanium, magnesium, molybdenum, or tungsten. It would then be economically feasible to use these costly hard-to-obtain materials, for then a thin skin with many of the desirable properties in these metals could be obtained. It has not been done yet, but it will be.

NEW MATERIALS

New materials and the readaptation of old ones will markedly affect product design and product manufacture. Take aluminum, for instance. At present, heat treating is a long and costly process as sheet must be cut and treated in batch lots. Development of a rapid continuous heat-treating process to provide a formable sheet of over 100,000 pounds tensile strength would rapidly expand present applications of aluminum and open up many new fields. A team of induction heating and electric atmosphere-controlled furnaces may provide the answer.

Magnesium is a relative newcomer to the materials field, but the supply is literally inexhaustible. It is one of the first elements to be obtained in large quantities from sea water by electrochemical processes. Alloys of magnesium, silver, zinc, and zirconium show considerable promise for commercial development as high strength sheet. Heat treating provides very high strength-to-weight ratios equaling or exceeding heat-treated aluminum alloys. Fabrication processes are being established and the material has a promising future. With the new material and new processes, more power will be consumed.

Titanium, long used as an alloying agent in steels and in compound form as a paint pigment, is winning a place for itself as a metal. A titanium alloy with about 56 per cent of the density of stainless steel has many things in its favor such as abundant ores, light weight, high strength, and outstanding corrosion resistance, but it is also a difficult and costly metal to produce. Engineers feel that it will be possible to substitute titanium alloy for stainless steel in many critical applications such as aircraft structural parts adjacent to jet engines with a 40 per cent weight saving. Due to its excellent resistance to chemical attack, titanium will be suitable for marine and corrosive atmospheres.

Many lesser known metals such as zirconium, molybdenum, tantalum, columbium, hafnium, vanadium, and chromium are at present relatively unknown, but all have, in metallic form, a high kilowatt-hour content. Each has some unusual property that makes it attractive. Hafnium, for example, has the highest melting point of any solid, 4,160±150 degrees Kelvin. Zirconium has high corrosion resistance to alkalis and certain acids including water. Molybdenum has a high melting point and when protected against surface oxidation, can be used as a structural metal in the 2,000–3,000-degree-Fahrenheit range. Tantalum and columbium have been used as stabilizing agents to give stainless steels higher corrosion resistance to mineral acids and to prevent intergranular attack at welds. Hafnium also has high corrosion resistance, even better than tantalum which costs eight times as much. Vanadium and chromium have unusual corrosion-resistant properties, and if they can be made in ductile form at reasonable cost, they will be very useful in the intermediate temperature range 1,000 to 2,000 degrees Fahrenheit.

Scientists feel that many of the puzzling problems with these metals will yield to intensive fundamental research on their atomic structure. It has been possible to produce superhard stainless steel at low temperatures. The reason is not known, but scientists expect to learn by studying

single crystals of exceedingly pure material. Nothing is known about iron, as it has never been obtained uncontaminated by impurities. As purity approaches perfection the properties change so abruptly that scientists are heartened that some day we may be able to base all fundamental properties on pure materials and then obtain the desired properties by controlled contamination. If this can be done, the ability to build "supermetals" will have been achieved.

Plastics too will play an ever-increasing part in the future. Already glass fiber polyester plastic automobile bodies can be obtained on a custom basis. They are light and nonrusting and may set a new trend in body design. Industry has long used glass-cloth melamine plastics for special navy applications, but cost has been a deterrent to general use. Reinforcement of styrene plastics with short glass fiber holds great promise as moldability, coupled with great strength, results. Costs may be initially higher than ferrous metals, but when their use is increased, costs will be reduced. Such materials are already on trial in domestic appliances and may well replace thermosetting laminates in door panels and other constructional elements. Fluorine plastics show unusual resistance to chemical attack and will stand temperatures up to 500 degrees Fahrenheit without serious loss of properties.

In this short article, it is impossible to discuss production in detail, but an attempt has been made to point out significant trends which will affect the utilization of electric power in industry. New devices, new materials, new processes all mean more power use. In the final analysis, the solution of production problems will be up to the scientists and engineers who will ever strive to find new ways to use electric power in our expanding economy.

Feedback System Engineering An Expanding Professional Field

G. S. BROWN
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This year, which marks the Centennial of Engineering, also might be said to mark the coming of age of a professional field which was in its infancy a century ago. Feedback system engineering has gone beyond the mere development of new techniques and processes, however; it has created an entirely new philosophy at the design and analysis level.

WITHIN THE LAST few years we have witnessed the widespread impact of feedback system engineering on engineering technology everywhere. A significant manifestation of this impact occurred a little over a year ago at the international conference on Automatic Control held at Cranfield, England, under the auspices of the British Ministry of Supply. For 5 days and several evenings speakers from Europe, the United Kingdom, and the United States presented a steady stream of papers on various aspects of feedback control in both man and the machine. The attendance was 300-odd and comprised professors from universities, leaders in industrial research, and practicing engineers in the manufacturing and process industries. The manuscripts ranged in subject matter from abstract theories to reports on engineering developments in feedback control. The proceedings[1] have since been published and comprise a scholarly document.

A similar but shorter conference was held at Atlantic City, N. J., in December 1951 under the auspices of the AIEE Committee on Feedback Control Systems. While the attendees, about 450, came largely from the United States and Canada, they represented almost a complete cross section of industrial and professional engineering activity, and were all professionally interested in the concepts, principles, and practices of feedback control at the systems level.

These conferences were but two of the many signposts that point to the widespread influence of feedback control in modern technology. The recent issue of *Scientific American*[2] devoted wholly to feedback control is a third. Not only are we witnessing evidence that a new professional field has emerged, but we can already note its influence on the day-to-day thinking of all kinds of professional people, on the obligations and responsibilities of industrial management, on the technical education of young men, and even on the routine behavior of people.

Full text of a conference paper presented as part of the AIEE Participation in the Centennial of Engineering, Chicago, Ill., September 10–12, 1952.

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Certain material included with this article appears in the book by Tustin[1] or in the article by Brown and Campbell in the *Scientific American.*[2] The author acknowledges the collaboration of his colleague, Professor D. P. Campbell, in the preparation of this article.

Feedback control is not, however, something brand new. On the contrary, it is as old as engineering itself. Lord Kelvin wrote about it, and James Watt applied it to the flyball governing of his steam engines a century ago. Its early industrial applications, however, were usually manual or semiautomatic. A human operator read instruments, a temperature or pressure gauge for example, and applied a correction to a process by turning a valve or adjusting a rheostat. He detected deviations of actual performance from some desired state of operation and performed a corrective manipulation. The human here served as the feedback link, the error detector, and the controller. He decided what the reading was, what it meant, and what should be done about correcting the process. But throughout the years the consistent increase in the tempo of industry brought about greater and greater complexity of equipment, greater need for precision and faster response of controllers. Eventually, power amplification was added to the instruments and the human was ruled out of the control loop as the instruments themselves replaced the action of the human muscle. Instruments which formerly had merely measured, indicated, and given data for inventory purposes, now measured, indicated, and controlled. Complex decisions and judgment that had been made by the human brain were soon performed, rather imperfectly perhaps, by mechanisms designed to approximate certain of the elementary human actions such as proportioning, anticipating, and integrating. These steps were very significant throughout all technology, for they freed the machine from the limitations imposed upon its operations by the shortcomings of the physical and nervous systems of the human. Thus was set loose a tremendously powerful technique that has resulted in the birth of feedback control system engineering. Throughout all industry, processes are daily being re-examined to see how automatization by feedback control systems can help to keep pace with our expanding technology and relieve man from drudgery.

THE STATE OF THE ART

THE KEY to the modern state of the control art is actually not distinguishable unless we look behind the maze of motors, pistons, wires, electron tubes, and brightly lit panels of instruments. What we find is a philosophy, a frame of mind, an engineering methodology of how to design and synthesize control systems.

Feedback system engineering as considered here is the co-ordinated creative synthesis of the process, the plant, and the instruments. The developments predicted for the future call for the creative co-ordination of teams of physicists, mathematicians, and technical specialists of many kinds, and culminate in engineering in which system synthesis overshadows analysis. Feedback control system engineering, as practiced under the demands of the mid-20th century, deals almost entirely with techniques that are new. It is not routine engineering. It is often a highly technical administrative job. It offers the highest professional challenge.

The groundwork for the feedback control system engineering techniques that exist today was laid at about the time the flyball governor was invented. The theorems of Laplace and Fourier, the studies in analytical dynamics by Routh, and the early statements on circuit analysis by Kirkhoff and others, were in existence, but no particular merger of the theory and practice took place until about the 1920's. Then came a gradual emergence of technological method. Today it dominates the practice of design and development. First men began to formulate and to solve mathematical equations that designated the behavior of the control systems they intended to build. Often the results were rather surprising. As the systems became more complex, man's capacity to guess correctly did not bear mathematical scrutiny. Slowly from the mid-20's until the late 30's, the methodology grew and influenced control system designs, but even when World War II began, we were barely muddling through. Statics had not yet given way properly to dynamics in our thinking.

With World War II came the integrated efforts of great numbers of men with adequate funds and with the stimulation of the desire for survival. They poured their complementary and supplementary abilities into a wide area of common activities. Scientists, who enjoyed abstract thinking, worked in harmony with engineers. Gradually, their efforts threw up a great umbrella of unified know-how for treating the control system synthesis and design problem. Boundaries between different fields of engineering and science collapsed. A free interchange of ideas led to the chemical and mechanical engineers' exploitation of the techniques of the communications engineers; aerodynamicists exploited electrical techniques of measurements and concepts of mathematical presentation; mathematicians forged ahead with theorems which, though only a few years previous had been so much abstract symbolism, were now useful.

As the general theory for the analysis and synthesis of control systems emerged, it became apparent that the theory itself was not enough. Some basis had to be found for speeding up the solution to design studies. The old era of the cut-and-try gadgeteer passed; the predetermined and predicted gadget became more frequent. A century ago many problems could be solved with relatively simple controllers which might be constructed by a clever inventor or technician. The World War II and subsequent controllers, however, demanded more exacting knowledge of the device or process to be controlled and of the basis for setting reasonable specifications. The coupling between science and engineering became very tight as the designer probed more deeply into the basic theory of processes. The calculations were tedious and long so charts, nomograms, and slide rules were invented for the solutions of special problems. Criteria of dynamic excellence began to emerge.

But a great vacuum still existed in the numerical data available to the engineer. Its presence stimulated whole classes of experimental testing and measurement studies on live systems: mechanical, electric, chemical, and aeronautical. Complete plants or mechanisms of systems were disturbed by test signals, and the response compared with the disturbance. It became convenient to write the describing equations for electric motors, amplifiers, hy-

draulic drives, and even chemical processes, in terms of their message-handling ability and to analogue them by means of passive and active circuits containing resistors, capacitors, vacuum tubes, and other simulation apparatus. By the application of the transient or sinusoidal test function, the use of operational mathematics, the exploitation of signal-flow diagrams and block diagrams with complex variable forms for transfer functions, the system engineer brought the whole vast and important theory of communications and electric circuit analysis to bear upon the analysis and synthesis of feedback control.

The changes in equipment design that today are upsetting the peace of the industrial and military scene stem from the energetic collaboration of bold, imaginative, unconventional engineer-scientist teams. Today's new apparatus is gone tomorrow. Improved performance of a control system and great new systems of control no longer come into being merely by men at drafting boards applying themselves diligently to variations upon components. Rather they begin with the system engineer who draws up a unified scheme for control whether his subject be a missile or an industrial process. He pulls together his team of abstract thinkers, scientists, and creative engineers. He poses such questions as: "Are we exploiting magnetic phenomena so that the dynamics of our energy conversion members respond in an optimum manner to the most data we can send over our channels, or is it possible that by matching process-reaction dynamics with instrument dynamics we can have less hold-up in our process and hence not build such massive structures?"

The rise of ideas which have led to the frame of mind, the art so to speak, developed because system engineers found a need to be more quantitative as they were faced with the tasks of processing more and more material in less time with less space, and to closer tolerances. Their practical problems had become more complex, more sophisticated. They were face to face with the expanded tempo of industry. They wanted numbers to measure physical phenomena, they wanted to replace the guesswork and cut-and-try gadgeteering by procedures based upon modern scientific discoveries and mathematical law expressive of the dynamic state of system behavior. They had to substitute exact design with confidence for gadgeteering and empiricism. They became vitally interested in the useful aspects of modern science. They learned that analysis must precede construction, especially for systems so complex that they take 5 or 10 years to build and thus often outspan the engineering and managing ability of any one group of men involved in the task. They know that the creation of the systems demanded by the future will embrace even greater scope and complexity and call for the effort of closely coupled teams of widely different specialists whose knowledge of the modern discoveries of science, engineering, and management is first-rate.

WHERE DO WE STAND TODAY?

On all fronts automatic control is flourishing, so much so that we can be pardoned if we view the race with alarm. The robots are here. Our schools are turning out the engineers to design their components and to conceive of them in toto. Industries are springing up every month to build heretofore unheard of mechanisms. Older industries have shifted over to new lines of equipment. Researchers are probing new frontiers. Conferences almost every few months are devoted exclusively to the technical and scientific aspects of the problem.

The past accomplishments of this new school of engineering are truly noteworthy. Some of the great technological areas* wherein feedback system engineering plays a predominant role are found in:

1. *Process Industry*
   (*a*). The production of nylon, an entirely synthetic material.
   (*b*). The numerous aromatic compounds from the straight chain, or aliphatic, materials of petroleum developed by Carbide and Carbon Corporation.
   (*c*). The mass production of penicillin and other mold-generated specifics.
2. *Nucleonics*
   The extraction of fissionable material and the development of the atomic bomb.
3. *Power Devices*
   (*a*). Atomic power plants, either stationary, water-borne, or air-borne.
   (*b*). Gas turbines and the whole class of jet propulsion systems.
   (*c*). Industrial control systems of many kinds.
4. *Metallurgy*
   The mass production of steel and its alloys, titanium, combinations of ceramics and metals.
5. *Aeronautics*
   (*a*). The control and guidance systems of subsonic and supersonic missiles and aircraft.
   (*b*). The development of the helicopter.
6. *Miscellaneous*
   (*a*). The great development of computers, industrial, scientific, and military.
   (*b*). The miscellaneous servomechanisms in military fire-control systems.
   (*c*). The array of regulators and servomechanisms in instruments for industrial and scientific research purposes.

Man himself is frequently the process being controlled. Already feedback concepts have given new insight into his nature and the operation of his body. They have provided new and fruitful analogies for the pyschologist, the philosopher, and the physiologist. The treatment of patients by X ray and diathermy in which feedback limits the amount of medication are becoming commonplace. The study of anesthesia,[3] the kidney, automatized breathing iron lungs as an aid to poliomyelitis therapy, and other medical problems shows evidence of a sharp upsurge in the use of carefully planned system engineering with feedback control entering the work early in the medical phase.

* From a tabulation of engineering fields in which the systems problems are dominant, presented by Dr. C. C. Furness before the American Society for Engineering Education at the Centennial of Engineering, September 5, 1952.

Now, unlike a century ago, the theory and practice of control seem to be advancing to some extent in synchronism, though the deeper we probe the more we realize that conventional methods of analysis are inadequate. Thus, the pressure of physics and mathematics still continues. The physics laboratory has moved into the production plant. Today it is not enough to know the temperature and the pressure under which a chemical reaction may be taking place. We seek to know the molecular weight of the material being made. We search for measures of its color, its odor, its ability to transmit light, its infrared absorption, the amount of moisture taken up by the material. So men have gone to higher strata of measurement. They shoot missiles into the sky, they look at materials with special radiations, they spin propellers in the streams, they beam sound waves through various media, all in an effort to become more quantitative about the dynamics of what they are doing. This calls for great amounts of study about what to do with the measurements when the data are available. After all, it is one thing to decide how to measure the viscosity of a fluid; it is another thing to know what knobs on the process to turn or what ingredients to add to change the stickiness of the fluid by an exact amount, yet these are the frontiers being attacked today.

TRAINING MEN FOR THE JOB

FEEDBACK CONTROL system engineering is now here as a new rapidly growing profession. It is one that demands a type of system thinking that ignores traditional categories in both educational and industrial organizations. The training of young men for this new level of professional competence requires a reorientation of our ideas of postgraduate engineering education. The proper utilization of this new kind of talent requires an awakening and a reorientation of the attitudes of engineering management. At all management levels, financial, technical, operating, and maintenance, we must be prepared to recognize control with its benefits and its limitations. Today we have a great paradox; we almost cannot afford not to have a great deal of control. However, compromises must be made between costs and performances. Old methods of design are being forced to yield to new ones with closer coupling between instrumentation limits and the costs and strength of steel tanks. Finally, men who have been used to operating the controllers of 1930 vintage are receiving more and more often the 1950 vintage. They now must learn new tricks of why they work, how they work, and how they can be repaired. Thus, the student of industrial management, the engineer involved in research, development, and design, and the man who keeps the equipment running, all must become conversant in a complementary way with feedback control system engineering.

FEEDBACK SYSTEM ENGINEERING AS A PROFESSION

CONTROL SYSTEM engineering requires: first, an analysis of the whole system in terms of the independent, partially independent, and dependent variables; second, an integrated design of instrument, process reaction, and controller; and third—which is too often the first—the initiation of mechanical design, fabrication, and, finally, the test. Perhaps the airplane is the unique example to cite here. The modern jet fighter is no longer merely an exquisite airframe but a unique optimization of a weapon, a killer, and a navigable flying machine. The coupling required between all branches of science and engineering for its creation is extremely close.

The concepts of automatic control are now developing from those that call for the mere assembly of standard components, to the synthesis of unique components evolving along the pattern of servomechanisms design. Such further steps as the incorporation of computational aids in automatic control for the simultaneous control of several variables from combinations of environmental and quality information, in such a way as to require the instant-by-instant solution of complex groups of equations during the operation of a plant or system, are clearly indicated trends. Such requirements often call for computers as part of the system.

These developments require men with an engineering education that is broad, and the environment wherein they work must be one within which people are not afraid to experiment with new things. The term "feedback system engineers"[4] is now commonplace for the kind of person who carries the responsibility for this kind of engineering work. He is not only a theorist, but he carries sufficient acquaintance with practice to mingle freely with the technician as well as with the scientist.

The training of feedback system engineers offers educators a real challenge.[1] Among the many deterrents to their efforts is the fact that engineering schools, and the engineering profession itself, are usually organized in departments; mechanical, electrical, and even finer subdivisions. To many students, mechanics, thermodynamics, electronics and circuit theory, or mathematics are often regarded as isolated areas of activity. The undergraduate student rarely is conscious of the all-important aspect of cross-fertilization among these fields, but even the elementary feedback control system incorporates them all.

Education for leadership at the broad creative engineering level cannot be accomplished by simply adding together the old specialties. The solution is not to condense the old specialties and crowd them into a new curriculum, but to provide a new synthesis that will produce not a jack-of-all-trades, but a master of a new trade, a specialist in the concepts and techniques of feedback system synthesis.

Adequate scholarly accomplishment in the field of feedback control calls for many attributes of the scientist. It requires advanced work in the fields of mathematics, physics, chemistry, measurements, communications and electronics, servomechanisms, energy conversion, thermodynamics, and computational techniques, in addition to a sound undergraduate training in physics or engineering. It is now being offered in the graduate schools of several American colleges and universities.

Particular stress must be laid on the science and practice of measurement, which is perhaps the most important topic in automatic control, first, in order to ascertain the proper

quantity to be measured, and second, to prescribe the dynamic accuracy required. The measurement of product quality represents challenging new areas of basic research, extending to the field of nuclear techniques. The field of electronics and electromagnetics appears to offer more opportunities for improved measurement and amplification of signals than any other means. Vacuum-tube amplifiers, pulse techniques, storage and memory techniques, are in everyday use and must be included with a student's training.

Familiarity with mathematics of differential equations, functions of a complex variable, statistics, and nonlinear techniques, as well as knowledge of physics and chemistry of the mid-20th century variety, are basic to the program.

A vital, but much neglected, topic is that of energy conversion and energy transfer, in relation to dynamic processes. Servomechanisms courses offer excellent opportunities to introduce this topic and to train students to think creatively, initially in terms of abstractions and finally in terms of different engineering specialties.

Computational aids such as differential analyzers, computers, or simulators, are needed in the analysis and synthesis of full-scale problems, though they are no substitute for keen analytical thinking. Contact with these devices is a vital part of a student's training.

RESPONSIBILITIES OF INDUSTRIAL MANAGEMENT

If full advantage is to be taken of the existence of academic programs of the kind just described, industrial management must reorientate its attitudes towards engineering organization and raise its thinking to the system level. The need is the integration of widely different professional fields for plant synthesis and design with emphasis on functional dynamic behavior and not merely on type of equipment. A qualified system engineer must head the technical staff. To support him a line organization is preferable to a staff organization. He should not have to battle with policies under which the chief mechanical engineer is autonomous when dealing with things mechanical. Likewise, his chief electrical engineer cannot be autonomous in dealing with all things electrical. All departmental chiefs must learn that in a new modern art, science is often the master of engineering and that the modern tricks of their trade must evolve through departmental teamwork wherein they catalyze the integration of individual specialties and apply the judgment factor.

Administrations of engineering organizations must be made aware of the importance of this problem, and universities and technical institutes must give young men the background and tools necessary to cope with these tasks and to staff the organizations.

CONCLUSIONS

Even in the most robotized of the automatic factories there will be many men. We are far from the time when man can be replaced. Nor should labor fear the widespread growth of control. On the one hand, the use of control coaxes him none too gently into taking more responsible jobs, making bigger decisions, and using his mind as well as his hands. On the other hand, it gives him greater freedom and leisure for hitherto unreachable creative pursuits.

To many thinkers, feedback as an evolving concept is as important as anything now in sight. If the atmosphere in which our study of machine systems takes place is profound and invigorating, we should be able to give ourselves the collateral capacity to think about problems arising in human systems. Already feedback as a concept has given us a new insight into the nature of man and the operation of his body. Over and above these virtues we find the need for engineers to apply this kind of imaginative thinking to their actions, both long and short term, as citizens. Engineers as a class should always think comprehensively about the effect on society of their own actions if engineering is truly a profession.

It should not be out of place here to contemplate human society as a large feedback system wherein man's intellect is the feedback link between his environment and his conscience. Character and the human spirit afford value references. If true, it follows that the attitudes of mind we are trying to encourage in the various technical fields of feedback control may be stepping stones toward a new type of thinking and a new way of looking at the social problems of the 20th century.

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Aerial Survey Service Established

An aerial survey service to speed layout, assure accuracy, and effect savings in establishing microwave transmission paths has been established by the Engineering Products Department of RCA Victor. Data and photographs will be provided to form a complete analysis of any projected microwave system. Included in the survey will be general topographical details, a study of possible station sites, aerial photographs, and charts delineating the microwave paths.

The surveys are designed to expedite the laying out of both long-range and short-range microwave communication, channeling, and telemetering systems for right-of-way users such as gas and oil pipe lines; water, gas, and electrical utilities; radio, telegraph, and telephone companies; railroads, and government agencies. State-wide police radio networks, forestry, and other public services can derive benefits from the new service.

The plotting of microwave paths from airplanes equipped with radar, aerial cameras, and other navigational instruments was first undertaken in the establishment of television networks. The method was proved basically sound and the most accurate means of scouting possible routes prior to buying land and constructing stations.

Shore-Based Radar for Harbor Surveillance

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W. R. GRISWOLD

The advantages of shore-based radar to aid in the movement of marine traffic are discussed. Installations in the ports of Long Beach, Liverpool, Boston, and New York are described. The advancement of the three elements of harbor surveillance: radar, 2-way communication, and ship identification, are evaluated.

ONE OF THE MORE recent and most interesting applications of radar in the civilian world is the use of shore-based equipment to aid the movement of shipping in thick weather in the major seaports of the world. This is analogous to the ground-controlled-approach system used in landing airplanes under similar conditions. However, in the marine field one does not use the word "control" as this implies acceptance of responsibility for safety of the vessel, which by law and custom must remain in the hands of the master.

In considering the application of shore-based radar to harbor surveillance the question immediately arises as to what service this radar can render, especially in view of the fact that ships are being fitted with their own radars. Shore-based radar is a useful aid for a number of reasons. One of these is that it is probable that all the vessels using a harbor will not be equipped with radar, and one unequipped vessel blundering around in the fog can raise a great deal of havoc with an otherwise orderly motion. A second reason is that large vessels require a great deal of advance warning as to objects in their path and their own radar may not provide a comprehensive enough view, as part of the channel may be around the corner or beyond the range at which they desire to operate their radar. Also, radar data are crude at best and do not provide all-inclusive information. In addition, the shore radar effectively provides communication between vessels in the harbor and therefore can add a great deal of information beyond that obtainable from the ship's own radar.

The economics of the situation are also of interest. The operating cost for an average vessel amounts to about \$2,000 per day, and it is, of course, many times this for large vessels such as the *U.S.S. America* or one of the *Queens.* Therefore, even the few hours lost waiting to enter the harbor rapidly amounts to a sizable sum. For instance, in New York it was estimated that 104 hours were lost in the month of August 1950. Knowing that New York harbor averages one ship per hour and assuming only one hour's delay per ship, the loss amounts to \$10,000 a month. However, as ships tend to come in groups and to lose more than an hour in a particular fog, \$20,000 a month is probably a more realistic figure.

As harbor radar systems are usually designed by radar engineers, the radar problems appear to them to require just straightforward engineering and they find more interesting problems in the field of communications, ship identification, and in the designs of auxiliary equipment to simplify the working out of operational procedures.

Communications turn out to be a serious problem. This may surprise many when it is remembered that the art of radio communication had its beginnings in the marine field. However, as often happens to a pioneer, the industry became set in its ways and hampered by lack of finances and, later, by lack of frequency space, marine communications have fallen behind other services. Most oceangoing vessels still do not have any radiotelephone, and on those which do, the telephone is more often than not located in the radio shack and not on the bridge. There is, in general, no direct voice channel for the use of the master of the vessel in the ordinary communications involved in handling the ship.

To help correct this situation, the last Radio Frequency Conference at Atlantic City, N. J., made available a very-high-frequency band in the neighborhood of 160 megacycles for ship-to-ship and ship-to-shore radiotelephone.

However, few ships are as yet fitted with this type of equipment. In order, therefore, for the radar operator to communicate with the shipmaster, portable equipment has to be carried on board the vessel by the harbor pilot. Except for the inconvenience of having to carry the equipment around with him, this is a very natural arrangement, as it is almost immediately obvious that radar information is more easily interpreted and used by the harbor pilot than anyone else concerned with the problem.

In the harbors of the United States which have so far been fitted with shore radar, communications have been established using frequency-modulated transmission and simplex operation. The use of the simplex system with everybody on one large party line has the advantage that all can listen in on the information and also that pilots on different vessels can communicate with each other. The British, however, have adopted amplitude modulation and a duplex setup. This, of course, will prevent any common use of equipment on both sides of the Atlantic and unfortunately reduces the incentive to fit permanent equipment. Sooner or later in the interests of economy a common system will have to be worked out.

The portable equipments radiate about 1/4 watt and

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Figure 1. British 6-channel very-high-frequency portable harbor radiotelephone

Courtesy British Telecommunications Research Laboratories, Ltd.

are fitted with elementary 1/4-wave antennas. This limits the maximum range to approximately 15 miles unless the shore station is fitted with a high-gain antenna. Also, the operator must take care not to stand in the shadow of the ship's superstructure.

The shore end is equipped with a high-power transmitter. American transmitters normally radiate about 60 watts, whereas those used overseas operate in the 40-watt region. The land stations also have better receivers than those available at the portable end. The antennas vary from simple quarter wave to very complicated high-gain ones. Figure 1 shows a typical British portable set and Figure 2, which shows a Long Beach, Calif., pilot boarding a ship, dramatizes the whole communication problem. In order to gain an over-all appreciation of the harbor surveillance problem, a few typical installations are discussed here.

LONG BEACH INSTALLATION

THE FIRST United States harbor to be equipped with radar was that of Long Beach. Figure 3 shows a relatively simple chart of this harbor. A nearly straight breakwater has two fairly large openings and deep water continues close to this breakwater. The inner harbor and dock area has its major entrance in the center of the chart. On the left is the entrance to another docking area which eventually connects to the inside of the main harbor. Most traffic entering the harbor after coming through or around the end of the breakwater makes directly for the main dock entrance, so there is a minimum of cross-traffic. This is an important point as it simplifies matters tremendously. The pilothouse in which the radar is located is just on the south side of the main harbor entrance and is an ideal site for a harbor surveillance radar.

Figure 4 shows the radar presentation of the same area. The breakwater with its openings shows very clearly about 3 miles from the harbor entrance and a great deal of the detail of the inner harbor is apparent. The side entrance and the canal with its two bridges also show very clearly. The radar is used to bring ships into the inner harbor, and occasionally right up to the docks.

The radar site is shown on the cover. The antenna is mounted on top of a 125-foot-high oil derrick with the transceiver located in the shack farther down the derrick. The indicator is mounted on the pilothouse at the base. The radar used is an *X*-band, or 3-centimeter, equipment. It has an eight-foot scanner which gives a 1-degree beam which is sufficiently sharp to resolve a ship passing through the entrance to the outer breakwater. The pulse length is 1/4 microsecond, giving a resolution in range of the order

Figure 2. Long Beach harbor pilot boarding an incoming vessel carrying portable frequency-modulation radio equipment for communicating with the shore-based radar operator

of 50 yards. A single indicator is used which has a 12-inch cathode-ray tube. This system has been in operation for 4 years and has been adequate for this harbor. A large amount of shipping has been aided in bad weather and the users have come to depend on the service.

LIVERPOOL INSTALLATION

A SECOND radar-equipped harbor and one increasing in the scale of complexity is that of Liverpool, Eng-

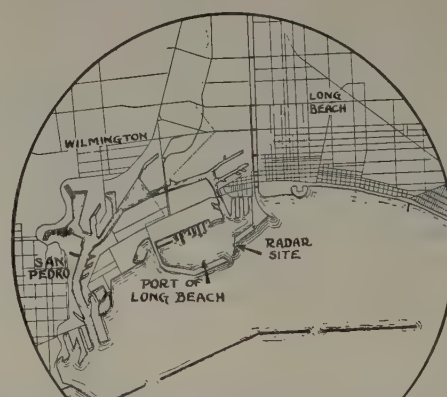

Figure 3. Chart of Long Beach harbor

Figure 4. Appearance of Long Beach harbor on the radar scope

land. Figure 5 shows a highly idealistic view of Liverpool harbor and the radar coverage patterns on the multiscope indicator. This harbor has certain peculiarities which make radar particularly useful so that it was the first harbor in the world to be fitted for radar assistance. The docking area is located at the head of the navigable portion of the Mersey River. From the mouth of the river a man-made channel extends approximately 11 miles out to sea. This channel is formed by two stone training walls which are awash at low tide. The mean tides in Liverpool are approximately 30 feet. This rise and fall of the tide would make the loading of a vessel tied up to a normal wharf almost impossible and therefore the docks in Liverpool have locks across their entrances to maintain the water level at approximately that of high tide. This means that there is only a very short period of each tide in which vessels can enter the docks. It becomes, therefore, more than ordinarily imperative for them to catch the tide.

The critical need for catching the tide and the fact that Liverpool has a great deal of bad weather, interested the Mersey Dock and Harbor Board in the use of radar as soon as it was available after the war. They therefore had a special radar built for this purpose, which at the time of its installation, was one of the finest radars every produced.

It is an X-band equipment having a 14-foot scanner mounted on an 80-foot tower. This scanner gives a half-degree beam, which is sufficient to resolve a vessel passing into the entrance to the channel some 11 miles away. The pulse length is again 1/4 microsecond, providing suitable resolution in range.

However, if the whole channel were shown on a single indicator, the operation would be made unnecessarily difficult. Therefore, the radar was provided with six indicators. Four of these are used to cover different sections of the river, the fifth shows the whole scene, and the sixth is available as an instantaneous substitute for any of the others that might happen to fail. These indicators have 15-inch cathode-ray tubes.

Figure 6. Liverpool radar site

Figure 7. Liverpool radar indicators

Figure 8. Appearance of Liverpool harbor on the radar scope

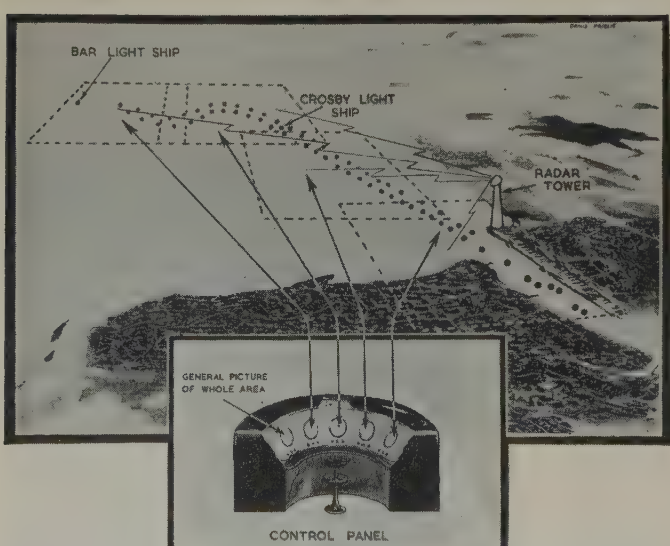

Figure 5. Artist's conception of Liverpool harbor

Figure 6 shows the radar site with the cylindrical concrete tower supporting the antenna. Adjacent to that, although not shown, is a steel tower carrying directive antennas for the communications system. Figure 7 shows the six scopes arranged in a semicircular console, while Figure 8 shows the total radar coverage of the harbor. Each of the indicators of this radar is provided with a transparent overlay across the face of the tube.

The buoys are engraved on one side of the overlay and illuminated in red; a grid is engraved on the other side and lighted in green. By proper adjustment of the illumination, either the buoys or grid or both can be observed.

A vessel passing up the channel is handled as follows: Its position is recorded from time to time on the overlay with a grease pencil. A line is drawn connecting these

points and projected ahead of the vessel. The most important information is whether or not the vessel is maintaining a course parallel to the buoy line or is opening or closing the buoy line, and this is the primary information transmitted to the pilot. In addition, as the vessel passes each buoy, the distance from the buoy is given. This is measured by means of a small ruler held up to the overlay as needed. Being British, these distances are given in cables, a cable being 240 yards.

Occasionally the distance to a particular navigation aid or to an approaching vessel is required. This is measured off with the same ruler. Once in a while the bearing to a particular navigation aid is required. This is measured by means of a small protractor held up to the overlay and used with reference to the grid lines. Protractors giving either true bearing or offset for magnetic variation are available.

Although this method of obtaining the data appears to be a bit cumbersome, it has proved most satisfactory in Liverpool, where 4 years of practice have reduced it to a fine art. Also, although the channel is long and somewhat tortuous, all traffic is constrained in a line by the training walls and there is no cross-traffic. This greatly simplifies the problem.

In this connection one interesting item on ship handling is that the master of a vessel proceeding in thick weather is more afraid of an anchored vessel than of one underway. This is because if another vessel is underway, it can do its part in any necessary maneuvers, whereas if it is anchored, it cannot move and takes considerably more room than its own length because of its anchor cable.

As this was the original harbor radar installation, the work done there has served as a basis for all subsequent systems. Incidentally, both the Long Beach and Liverpool radars are Sperry-built.

EXPERIMENTAL HARBOR RADAR

On their trip to England in 1951 to study the Liverpool harbor radar system, the authors also examined an experimental harbor radar made by Decca Company and installed at Southampton. This radar was also X-band and provided with a 14-foot, half-degree antenna.

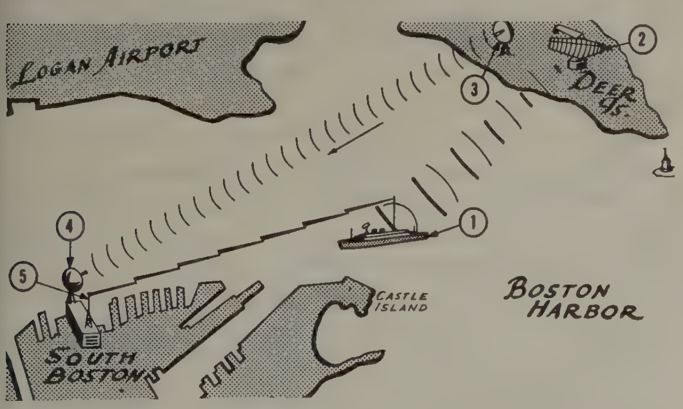

Figure 9. Artist's conception of Boston harbor installation: ship (1) reflects signals to Deer Island Station (2). These are relayed from (3) to South Boston Commonwealth pier (4), and from (5) the information is sent to the pilot on (1)

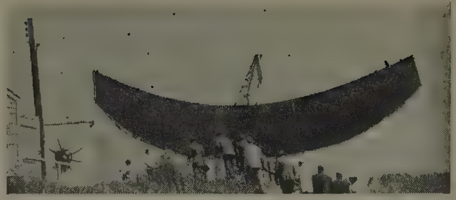

Figure 10. The 41-foot antenna installed in Boston harbor

Courtesy Raytheon Manufacturing Company

Figure 11. Typical radar presentation of outer portion of Boston harbor seen on 16-inch scope of number 1 indicator, Deer Island, with names of important landmarks added

Courtesy Raytheon Manufacturing Company

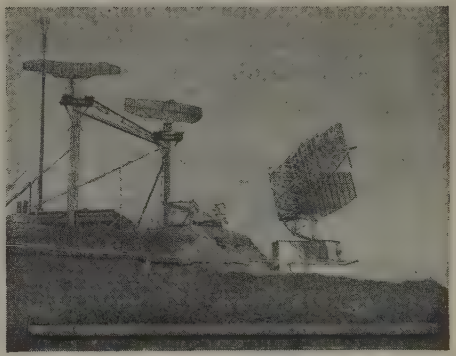

Figure 12. New York harbor radar scanner installation at Fort Wadsworth

Courtesy The Port of New York Authority

The pulse length, however, had been shortened considerably, to 0.06 microsecond, providing very precise range resolution and presenting a very fine radar picture.

A significant auxiliary service was also being demonstrated. By means of a microwave radar relay link, the radar picture was remoted to a point some 4 miles distant. A probable use for the radar relay is in complex harbors which would require more than one shore-based site. In such a case the links may provide an extremely useful service in relaying all radar data to the control center.

LE HAVRE PROJECT

This brings up another interesting harbor radar project; namely, that of an equipment for Le Havre, France, which has been built by Raytheon Manufacturing Company. Their equipment was set up for initial trials in Boston harbor. In this system a radar relay to transmit the information from the antenna site to a control station was also used.

BOSTON INSTALLATION

Figure 9 is an artist's conception of Boston, Mass., harbor giving the location of radar on Deer Island on the north side of the entrance to the harbor, and the path of the microwave relay to Commonwealth pier in South Boston, which was the operating headquarters. From here the piloting information was sent by radiotelephone to the ship.

The most interesting technical departure in this system is that it uses *S*-band, or 10 centimeters, for the radar rather than the conventional *X*-band, or 3 centimeters, used by other harbor radar projects. The claim is made that 10 centimeters is more reliable with respect to rain clutter than 3. It is true that rain obscures 3 more than 10 centimeters if all other things are equal. However, it has been found that the improved resolution obtainable with the same size antenna at *X*-band and the use of certain other circuits in the receiver reduce the rain clutter to a negligible amount except in a most torrential downpour. For instance, in 3 years of operation at Long Beach and Liverpool, no loss of service due to rain had been reported.

To achieve the same beamwidth or resolution, a 10-centimeter antenna has to be three times as big as a 3-centimeter antenna. Raytheon therefore has built a 41-foot antenna for their *S*-band system so that it will be comparable to the 14- to 15-foot ones normally used in *X*-band.

This is one of the largest antennas built and is quite a wonderful engineering and manufacturing feat resulting in a fine radar. There is, however, always the consideration that the resolution would be improved by a factor of three if the antenna were fitted for *X*-band.

This antenna and the general radar site of Deer Island in Boston harbor are shown in Figure 10. The small parabolic reflector to the left is the antenna system for the radar link to Commonwealth pier in downtown Boston. The outer portion of Boston harbor as seen in one of the scopes appears in Figure 11. The channel buoys are clearly delineated.

Figure 13. Appearance of New York harbor on the radar scope with coastlines and identifying data added

NEW YORK HARBOR RADAR

Both Raytheon and Sperry have been aiding the Port of New York Authority in their recently completed experimental trials of radar for New York harbor. This area is probably the most complex of the harbors yet to be provided with radar aid. Not only does it cover a large geographical area with a winding channel, but the amount of cross-traffic from ferry boats and particularly car ferries and other barge traffic in the upper bay far exceeds that of any harbor now using radar. This makes for an extreme degree of operational difficulty.

Experimental installations have been made at Fort Wadsworth, which is on the Staten Island side of the Narrows. See Figure 12. The appearance of part of New York harbor on the radar scope is shown in Figure 13. The chart outlines have been drawn in to show how the radar picture corresponds to the actual geographic outlines. This illustration also conveys some idea of the complexity of traffic in the upper bay. In actual use, two scopes would be used to cover this area; one scope covering that portion from Ambrose Light Ship to the Narrows and the second covering the upper bay. To instrument New York harbor properly, a complete second radar installation would be needed for the Hudson River dock area, which is above the part shown in the illustration. A possible location for this radar would be at Castle Point on the New Jersey side. These two radar installations would cover the majority of the transatlantic and passenger traffic. They leave unaided however, Raritan Bay, Kill van Kull, Port Newark, the East River, and the approaches from Long Island Sound.

The initial installation was made only to get some idea of the complexity of the problem and the feasibility of its solution. Most of the time was spent in working out methods of keeping track of vessels in the harbor and providing them with as nearly instantaneous information as possible.

Most of the work was done with *X*-band equipments. These sets went through a period of development and the two *X*-band equipments finally were made to operate with approximately half-degree beams, 1/4-microsecond pulses for the shorter ranges, and 1/2 microsecond for the longer ranges. Near the end of the trial period, Raytheon also installed a 10-centimeter equipment complete with a 41-foot scanner.

A few experiments that it was hoped would lead to an economical and simple means of identifying a particular ship on the radar screen were tried out in New York. They embodied an idea that originated with Sperry in England and will also be tried out in Liverpool.

Figure 14. Appearance of Gravesend Bay on the radar scope with identifying data added. (Left) Before identification of the ship. (Right) With identifying radent tail

In Figure 14, the vessel has turned on her identification gear and the identification mark shows clearly as a long dash on a radial line from the vessel to the radar, slightly beyond the vessel. There is no doubt which vessel is being identified.

During normal operation it is presumed that this identification will not be used continuously. However, if there is a doubt in the minds of the shore operators as to the identity of one or several ships, they will ask each ship in turn to identify herself so that the tail on the echo will first appear on one target and then on another until all are identified.

The way in which the proposed identification system operates is approximately as follows: In addition to his walkie-talkie, the pilot carries on board with him a means of picking up the radar signals and returning them to the radar which displays them in the scope.

Thus the pilot used a microwave horn and crystal video receiver to detect the radar signals. After increasing the pulse to 1 microsecond, the output of this receiver was in turn used to modulate the final stage of his very-high-frequency portable voice transmitter. By modulating only the final stage, sufficient bandwidth was maintained to handle a 1-microsecond pulse. This very-high-frequency pulse was in turn received on a special wide-band receiver at the shore site. The output of this receiver was then inserted in the radar video.

Unfortunately this system required a clear 1-megacycle channel which cannot be made available, at least in the foreseeable future, in either the very-high- or ultrahigh-frequency band and the experiments had to be abandoned. However, the principles are sound and the Radio Technical Commission for Marine Service has appointed a special committee, *SC-16,* to give this matter further consideration.

Their approach to this problem is to use a microwave carrier for the return link to the harbor radar site. Radar beacon bands have been assigned in the 3- and 10-centimeter regions which are useful for this purpose. This will require that the pilot carry with him a complete microwave transponder as well as his portable radiotelephone.

The appearance of a part of the lower bay at the entrance to New York harbor is shown in Figure 13. Coney Island and Gravesend Bay can be seen on the right. Four of the channel buoys marking the upper end of Ambrose Channel are visible in the lower center of the picture. Two vessels can be seen in the channel. Various small ships and buoys can also be seen in the channel. Various small ships and buoys can also be seen in Gravesend Bay and it is desired to identify one of these vessels. As can be seen from this picture, it is not possible to identify any particular vessel, or in the case of a small ship such as the one being used, to distinguish it from a good-size channel buoy.

The Port of New York Authority has substantially completed its preliminary experiments and just what will happen in New York now has not yet been decided.

EQUIPMENT FOR HARBOR RADAR

This seems to complete the necessary equipment for using shore-based radar as an aid to harbor piloting; that is, the three necessary elements in the system are provided, namely, a high-resolution radar, a good instantaneous 2-way voice communication between the man at the radar and the man at the bridge, and at least the technical background for identifying a particular target echo to the man at the radar.

At least two harbors have been using this type of service for about 4 years and have found it very successful. Authorities in many other harbors throughout the world including India and South American countries have started investigations and experimental work in this field, so that the installation of this service on a world-wide basis appears certain.

Isotopes Used for Pipe Inspection

Isotope Products Ltd., Oakville, Ontario, Canada, have developed a new head for the gammagage which adapts the instrument for pipe inspection. Weak spots and blockages can be located readily with this isotope technique.

Isotope iridium 192 is contained in a 30-pound lead trolley wheeled along the top of the pipe. It is clamped over each weld as welding is completed. The isotope exposure is controlled by a remote cable which moves the source into position against the pipe. Exposures are about 1 minute; films are developed quickly in a mobile laboratory which follows the pipe-line construction.

Another isotope application to pipe lines is being made in the United States where a small amount of isotope antimony 124 is squirted into a products pipe line to mark the boundary between one product and another. When the last of one product reaches the pipe-line terminal, isotope radiation activates an alarm to warn the operator.

Power Limits of Transmission Lines

L. E. SALINE
ASSOCIATE MEMBER AIEE

THIS ARTICLE PRESENTS the results of studies of the factors which influence the power limits or design loadings of transmission lines. Recent investigations have shown the principal factors determining the loading of transmission circuits, particularly those for distances of 100 to 600 miles. Since there is a continuing trend toward the use of higher voltages, it is desirable to study their possibilities more completely over the entire range of distances expected for 230 kv and higher. Hence, the present investigation extends the earlier studies to include lines from 10 to 600 miles in length. The results are general as regards the stability limits (Base kva$=5.0$ kv^2) and may be applied to lines of any voltage level. The economic comparisons in this study pertain to the 287-kv voltage level, which is about in the middle of the range for 230 to 380 kv and fairly representative of the general economic picture for all voltages 230 kv and above.

The system used in these studies is shown in Figure 1. The line conductor is 800,000 circular mils copper equivalent ($r/x=0.1$). The sending-end generator and transformer rating which determines the sending-end reactance ($x_g=0.3/P_s$) corresponds to the transient stability limit (P_s) of the system. Two conditions of receiving-end reactance (x_m) were investigated: for one condition the receiving system had a fixed capacity and a relatively high reactance ($x_m=0.25$ per unit), and for the other condition the capacity of the receiving system was increased and the reactance decreased ($x_m=0.25/P_s$) as the stability limit (P_s) increased. The stability limits are based on clearing a 3-phase fault in 3 cycles by switching out one line section.

The results of the study of transmission lines 10 to 600 miles in length are summarized as follows:

1. The representative economic power limits of two parallel high-voltage transmission lines are shown on Figure 2. By representative economic power limit is meant the power received at the maximum stability limit which can be justified economically from a consideration of the cost of transmission lines, switching stations, compensation, and real and reactive line losses.

2. The basic system configuration which gives the representative economic power limits (Figure 2) essentially is independent of the range of receiving-end reactance considered.

3. The economic advantages resulting from heavier circuit loadings, reduced insulation, lower line losses, larger transformer units, and higher interrupting-capacity circuit breakers can be realized most readily in many cases by using higher voltage lines.

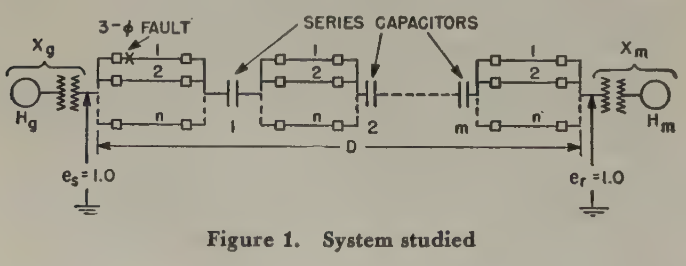

Figure 1. System studied

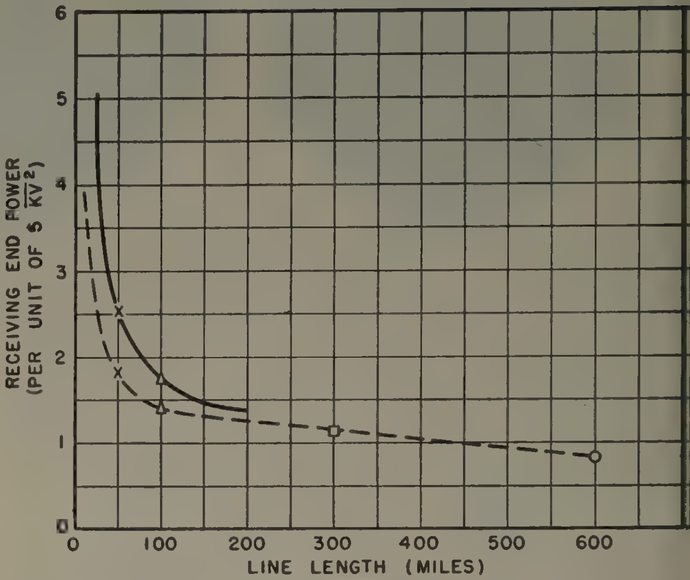

Figure 2. Representative economic power limits for two parallel high-voltage transmission circuits (based on 287-kv system cost data)

Distance Miles	Basic System Configuration: Point Symbols	Number of Switching Stations	Per-Cent Series Compensation
50 or less	X	0	0
100	Δ	1	0
300	□	4	50
600	○	5	75

4. Intermediate switching stations are an economic means of increasing the power limits of lines as short as 60 miles. The economic number of switching stations is a function of the line length, the number of parallel circuits, and the per-cent series compensation.

5. Series capacitor compensation installed at the intermediate busses may be practical and effective for two parallel circuits approximately 250 miles or longer. Series capacitors when used in this manner should be provided with quick reinsertion protective equipment.

6. For long lines the economic design loading per circuit may be increased by paralleling more than two lines. For a 600-mile line with six parallel circuits, three intermediate switching stations and 75-per-cent series compensation appears to be an economic way to increase the line loading depending on local geography.

Digest of paper 52-171, "Power Limits of Transmission Lines," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

L. E. Saline is with the General Electric Company, Schenectady, N. Y.

Management Looks Ahead in the Electric Power Industry

W. L. CISLER
FELLOW AIEE

The problems facing engineers in their capacity as part of management are considered in this address given before the recent Middle Eastern District Meeting. As the author was unable to be at the meeting in person, the address was televised, via a closed telephone circuit, from Detroit to the audience in Toledo.

THE PROBLEMS which keep me close to our operations during this period add greatly to the significance of the subject of this article.

As many readers may know, the Utility Workers Union of America, CIO, called what we believe is an illegal strike against The Detroit Edison Company on Thursday afternoon, October 23. Approximately 4,000 employees represented by that union in the company's Production, Substation, Construction, and other departments left their jobs. Since then, we have been continuing our traditionally fine service to the communities we serve through the outstanding efforts of our some 1,200 supervisors. Their skill and loyalty to the company in this emergency is a great inspiration to all of us who are responsible for the sound management of our business.

If I had planned to do so, I could not have made more dramatic one of the foremost problems which faces management today, and the tremendous responsibility we all have to find a solution for it than has this regrettable incident. Human relations will be management's most challenging problem in the years ahead. On our ability to face this problem objectively, and to use the same degree of skill and determination with which we have approached our engineering problems, may well depend the future of our industrial enterprise, and the continuance of our way of life.

In a day when electrical engineers are so much in the limelight for their engineering achievements, it is indeed significant that the AIEE has included a session devoted to management problems at this Middle Eastern District Meeting.

We have been credited, as a profession, with outstanding contributions to advances in the scientific and technical aspects of our lives. At the same time, we have been held responsible, and rightly so, for a share of the many human problems that have resulted from scientific and technical progress.

As engineers we have a reputation for being more interested in machinery, equipment, and methods than in people. Surprisingly enough, however, a large number of the engineering profession have grown into management jobs at all levels in all kinds of industrial enterprise; and I think that generally we have done a pretty fair job in that capacity.

A 1946 survey of the engineering profession by the Engineers Joint Council revealed that a higher percentage of engineers are engaged in some phase of management than is true of any other professional group. In their capacity as managers, engineers influence the success or failure of their companies, their industries, the nation, and even their country's role in world affairs. Their day-to-day relations with others and the decisions they make determine the effectiveness of the organizations which they head.

MANAGEMENT'S PROBLEMS

ENGINEERS IN MANAGEMENT positions face two important problems, one concerned with production and the other with human relations. The first has to do with the application of mechanical, electrical, and other scientific devices to production processes. The second, and increasingly important, has to do with bringing people together so that they can and will work together effectively in engineering, industrial, and commercial organizations.

The engineer, trained and experienced in approaching problems in an objective and scientific manner, is well equipped to use the open-minded approach in the solution of the problems that face management *today*. The engineer has already contributed a great deal. He has made power and tools readily and economically available so that *today* the American worker produces much more per hour than the worker in any other country. This has been done, not at the expense of the individual, but by the mechanization of processes and the utilization of energy derived from coal, oil, gas, and water, which now does 94 per cent of the work of our industries.

But our technical skill alone has not accounted for our great industrial strength. Certainly other nations have had their share of scientists, inventors, and engineers, but none has approached us in our productive capacity. Management has made possible the development of our great industrial system by bringing together such things as the necessary materials, skills, money, and organization. The most important element in this organization of resources, however, is a man-made resource, "management know-how."

In the past, management know-how has been directed primarily to the technical aspects of our industrial system. As we consider the problems which face us today, not only in our own companies, but in the nation and the world,

Essentially full text of an address presented at the AIEE Middle Eastern District Meeting, Toledo, Ohio, October 28-30, 1952.

W. L. Cisler is president of The Detroit Edison Company, Detroit, Mich.

it becomes clear that as we look ahead our greatest single challenge is the human relations problem.

Today, more than ever before, we realize that all problems facing management involve people. Whatever we have accomplished in the past has been through the good efforts of intelligent men and women, who have within themselves the capacity to take constructive steps and to solve problems. Management's role is one of organizing their efforts so that constructive purposes will be achieved.

To utilize our great productive potential effectively, management must create the conditions or the environment within which people can work together successfully. John S. Coleman, president of the Burroughs Adding Machine Company, expressed it this way in an article in the *Detroit Free Press:*

"A closer look at mass production discloses that the technique is primarily one of organization. It is a means of organizing a large number of people for a common task. Obviously, then, a positive and willing spirit of co-operation is crucial to success. To develop this spirit is not easy. For co-operation depends on the acceptance by all of a single purpose. Each individual must see the significance of his or her job in relation to the total enterprise."

Televised image of W. L. Cisler while addressing the AIEE Toledo meeting from Station WWJ-TV, Detroit. C. E. Ide, meeting honorary chairman, watches

How then, does management solve the problem of bringing our people to work constructively together in this mutual interest? Obviously, we have not yet learned the final answer to that problem. In all of our relations today that problem becomes a more pressing one. Not alone is it of concern to the managers of industry, but equally it must concern the management of our unions and the management of our governmental units, whether local, state, or national. The same kinds of problems face the United Nations in their search for a solution to international human relations.

What have we done in the past when faced with technical problems? As engineers we are all familiar with the part research has played in the advancement of our technical knowledge and skill. Industry has contributed its time, money, and man power to the solution of highly complex and difficult engineering and production problems. Our research has opened great new frontiers.

Right now, the electrical industry is on the threshold of such a frontier with respect to the possible production of electric power from atomic energy. The Dow Chemical Company and the Detroit Edison Company in a joint project, together with the Toledo Edison Company and others, are looking into the problem. We have established in The Detroit Edison Company a Nuclear Power Development Department whose job it is to carry on research and to help find the answers to this very important technical development.

We may unlock a new vast source of power. Whether it is used further to enrich human life or to destroy it rests on our determination and resourcefulness in solving the increasingly complex problems of living and working together with purpose and understanding. The engineer-manager must concern himself with these problems if we are to continue to benefit from his contributions to our technological progress.

Why then, should we not turn this highly effective tool, research, to the solution of our human relations problems? True, there has been in recent years some attention given to looking for answers by utilization of this means. But we must admit that we have lagged in the application of our scientific methods to the problems which deal with human relationships.

SCIENTIFIC APPROACH TO HUMAN RELATIONS

RESEARCH IN human relations can be just as important and rewarding as research in the physical sciences. Where a start has been made, the results are encouraging. Already, the importance of management leadership on the morale and productivity of employees has been amply demonstrated.

We do not yet have, in human relations and human organization, laws as positive and proved as $E=IR$. Until such laws are discovered, each of us must become an experimenter in human relations.

The light bulb was invented by a practical electrical engineer, Thomas A. Edison, who had the formula $E=IR$ and many other proved laws available for use. Nevertheless, it took this genius many months and hundreds of trials, most of them complete failures, before he was successful.

In the complex field of human relations, including industrial management, we are faced with a much more difficult problem than was Edison. We have no $E=IR$ and other certainties. Until we do have such laws (and they may be a long way off) it seems to me that the engineer who has become a manager of men should become a miniature human relations' Edison and will do at least the following things.

First, he will make the assumption that the democratic way of life is the best way thus far conceived.

Second, he will not be satisfied with democracy as a beautiful term or concept, but will insist on defining it for himself in such ways and detail that he can personally do something with it. This means that he will work out what engineers might call a democratic process with which he personally is willing to experiment. Let us not now think of this as a method for the solving of national or world problems. This is for the individual at his desk or place of work.

Research in engineering has brought about this marvel of communications by which the author, by long distance, was able to appear before the Fall Meeting in Toledo and deliver this address while seated at a desk in Detroit. But it is typical of communication in most of our human relations; it is 1-way communication. Our great need is for clearer, complete, 2-way communication. Although the problem can be stated simply, the variables and the difficulties are enormous. It comes down to the attitudes, methods, and specific skills by which we conduct our day-to-day personal relationships with individuals and groups.

Third, the engineer-manager will experiment with this democratic process not only in his business human relationships, but he will also seek opportunities for applying it in all areas of his living—in his home, his neighborhood, his professional associations, civic affairs, church, in all the human institutions with which he is associated.

Fourth, he will utilize and give support in every possible way to those who are using engineering and scientific methods in the study of human relations. He will find these people mainly in the colleges and universities. These groups are investigating the possible use of the principles of psychology, sociology, psychiatry, anthropology, economics, and semantics.

Some of you have dipped into these subjects and probably are unhappy with the inexact methods and absence of definite conclusions. But in spite of this, many of these organizations are making worth-while contributions and need our support. Many college and professional groups are doing a fine job of research in the field of human relations. The Institute for Social Research at the University of Michigan, directed by Rensis Likert, an electrical engineer, and the Cornell University School of Industrial and Labor Relations are good specific examples. Schools of Business Administration at the University of Michigan, at Harvard University, and other places are making fine contributions. Industrial Relations Sections at many other colleges are doing equally interesting and important research. The American Management Association has recently been doing what is essentially manager training, especially in the area of human relations.

Fifth, if his organization is of substantial size, the engineer-manager will set up within it an individual or a group whose purpose will be to aid him in a research approach to the organization's human relations problems.

In summary, he will accept greater responsibility for improved human relations through not only a sincere belief in humane and democratic principles, but in learning, inventing, and applying specific democratic methods and skills in his personal relationships and in seeing that they are used throughout his organization.

MANAGEMENT'S ROLE IN THE FUTURE

In the past, industry has been one of our greatest sources of strength in this country. We can easily out-produce the rest of the world, as clearly indicated by our performance in World War II. The rapid expansion of our electric power capacity by private industry following the war is an example of what can be done in the face of need.

At the time of the Japanese surrender we had developed the greatest military and industrial strength in the history of the world. Weary of war and the burden of military expenditures, we let our military strength decline. But our industrial strength was maintained and expanded.

We are now faced with the great task of rebuilding our military strength. It would be an overwhelming one had we also let our industrial organization and productive capacity run down. Much of our success in the future in keeping our industry and our nation strong depends on forward-thinking management, keenly alive to the social, economic, and political forces operating both at home and overseas.

We must have faith in the soundness of our industrial system and a firm determination to maintain its productive and creative force for the benefit of every individual and our nation. We must be continually aware that all things are accomplished through people and that management's primary responsibility is to co-ordinate their efforts in the mutual interest.

The scientific approach, which has brought great advances in technical fields, must be brought to bear on the solution of human problems, both in our companies and in national and international affairs. The American way of life is inherently effective and satisfying, and the managements of industry, unions, and government must work together to preserve the benefits it has brought us.

Management must find a way to bring about the most effective solution to our social, economic, and political problems. These many and complex forces merge in management, which must bring them into focus through an open mind and a sincere concern for the best interests of all.

Largest Helicopter Makes Flight

The United States Air Force's *XH-17*, the largest known helicopter, made its first flight recently at Culver City, Calif., at the Hughes Aircraft Company Airport. Built as a ground test model, the *XH-17* has been converted into a flight model following satisfactory tests of the jet-powered rotor mechanism.

The *XH-17*, an experimental heavy-lift machine, is expected to be the forerunner of powerful cargo helicopters designed to lift and deliver such heavy equipment as artillery, bridge sections, and trucks in areas inaccessible to conventional aircraft.

Professional Engineering in California

R. W. SORENSEN
FELLOW AIEE

IN THE MAGAZINE *Newsweek* for June 11, 1951, the following comment from a reader was published:

Engineer Shortage: An item in *Newsweek* May 21 (Business Trends) says that there is a shortage of "engineers." This problem could be easily licked. There is not much to the average American "engineer" anyway. A good shop foreman or machinist could be trained in a few weeks to do everything that most engineers do. The mass-produced American "engineer" is not a creative type like Gottlieb Daimler or Rudolf Diesel. In fact, he is coming to be noted far and wide for the jejune sterility of his mind. His overbloated reputation is due merely to educational snobbery and educational racketeering, coupled with the "caste consciousness" of too many personnel offices. The problem could be easily solved through a training program in the plants designed to restore a truly American equality of opportunity to our American industrial system.

Obviously, the fact that *Newsweek* will give space to such words indicates that Professional Engineers must develop some means to raise the general knowledge status of what constitutes Professional Engineering. Other reasons for raising the status might include: a present substandard professional criteria; an aim for perfection; too many substandard registered professional engineers; a demand for more engineers that can keep pace with our expanding knowledge of nature's laws; an acceleration of time-saving inventions; a need for an income that will better provide for self and family; and a deficiency of a code of ethics, inspiring leaders, engineers of culture, interest in community welfare, and devotion to the moral and spiritual elements of living.

With these items in mind, the author, AIEE representative on the California Board of Registration for Professional Engineers, presents an account of his stewardship. It is his duty to study the applications and examinations of all electrical engineers who desire registration and to present the results of that study to the Board in order that it may determine the right of each one for registration. A large majority of the present registered electrical, mechanical, chemical, and petroleum engineers were registered under the 1947 grandfather clause.* The recommendations to the Board for such men were not alone those of the author, for he had the help of a number of committees selected from the AIEE membership who supplied information to the Board as requested. No doubt some errors were made. Perhaps a very few qualified men were denied registration without the written examination. Also, no doubt a much larger number who would have failed a written examination and were largely specialists in limited fields to which they will confine their activities, were registered. Their lack of up-to-date broad engineering experience will not cause them to endanger life or property. Nevertheless, some nonregistered persons who think they should be registered tell us how much better they are than some of their registered associates. Those men always have the right to prove by examination their right to be registered.

The only legal basis for registration is the protection of life and property. With that in mind, the present status of registration in California is indicated by Tables I, II, and III.

Table I. California Professional Engineers Registered Under the Grandfather Clause

	Closing Date	Chemical	Civil	Electrical	Mechanical	Petroleum	Total
Grandfather applications	6/30/30		5,705				5,705
Grandfather applications	6/30/48	2,810		6,080	12,754	1,377	23,021
							28,726
Per cent of 1948 class		12.2		26.4	55.4	6.0	100
Per cent of total applications		9.8	19.8	21.2	44.4	4.8	100
Grandfather applicants registered		2,289	5,053	4,955	10,576	1,004	23,877
Per cent of applicants registered		81.5	88.6	81.5	83.0	73.0	83.3

It is interesting to note that 63 per cent of the engineers registered under the grandfather clause were college graduates and 37 per cent not college graduates, but only one-third of the noncollege graduates had no formal school attendance beyond high school.

Table II. Withdrawals and Number of Expected Applicants

	Grandfather Withdrawals		Probable Number Yearly Applicants		
	Number	Per Cent	1951–52	1952–53	1956–57
Chemical	40	1.75	50	100	380
Civil	2,000	39.50	1,000	1,030	1,200
Electrical	40	0.80	280	540	830
Mechanical	130	1.22	430	820	1,800
Petroleum	14	1.39	30	60	150
Total	2,224		1,790	2,550	4,360
EIT's* expected			3,000	5,400	4,500

* "Engineers in Training" are men who can pass the first half of the 2-day examinations but who have not had 6 years of acceptable experience.

*The grandfather clause grants boards of registration the right to register without the regular examination engineers who, in the opinion of the board, have shown evidence of being qualified by education and practice to pass a board examination. The clause is used only when a registration act is first passed and it contains a time limit.

Revised text of an address, "Raising the Status of the Professional Engineer," presented before the AIEE Los Angeles Section.

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Table III. Candidates Taking Written Examinations and Number of Valid Certificates Since the Five Classes Became Operative

	Taking Number	Passing Number	Passing Per Cent	Certificates Valid 6/30/51	Certificates Valid Estimated 6/30/52	Estimated Professional Society Members
Chemical	22	13	59.0	2,252		800*
Civil	1,279	369	28.8	5,938		2,200*
Electrical	118	44	37.3	4,910		4,000*
Mechanical	185	88	47.6	10,452		5,200*
Petroleum	19	15	79.0	982		2,600**
Structural				507	520	
Land surveyor				886	910	
EIT				3,365	4,670	
Total				29,337	31,326	

Registered electrical engineers: college graduates 63 per cent; nongraduates 37 per cent.
* Estimated as two times Los Angeles members.
** Includes petroleum, mining, and metallurgical engineers.

In addition to the work indicated by the tables, the Board has the task of handling each year about 500 complaints of law infringement. Each complaint requires considerable investigation. Sometimes the offender when informed by an investigator that he has broken the law arranges to observe all the legal requirements incident to engineering work. All too frequently, however, the Board must file court action. We have had good support in court decisions. Sometimes even in extreme cases where the Board and its members have been accused by persons not certified as being unfair and subjected to mandamus suits the decisions have been favorable for the Board. We have a record of one case in an eastern state where the court ruled that an engineer not registered could not collect payment for his engineering service.

In popular usage, the word "engineer" has come to include many men who are merely technicians or mechanics. In order to set a professional standard for engineers, many states now have passed registration laws defining the qualifications of a Professional Engineer. This article describes the provisions for registration in the State of California.

WHAT IS PROFESSIONAL ENGINEERING?

What is professional engineering? Who has the right to be a professional engineer? There is only one legal answer in California, and the same statement is probably true for every other state in the Union and also for Alaska, Hawaii, Puerto Rico, and Canada; namely, registration with an official Board of Registration, sometimes called a Board of Examiners.

How does one know what is professional engineering and what must be done by persons wishing to qualify as professional engineers? The California Act, Sections 6700 and 6701, reads as follows:

(*6700*) This chapter of the Business and Professions Code constitutes the chapter on professional engineers in the branches of chemical, civil, electrical, mechanical, and petroleum engineering. It may be cited as the Civil and Professional Engineers Act

(*6701*) "Professional engineer," within the meaning and intent of this act, refers to a person engaged in professional practice of rendering service or creative work requiring education, training and experience in engineering sciences and the application of special knowledge of the mathematical, physical and engineering sciences in such professional or creative work as consultation, investigation, evaluation, planning or design of public or private utilities, structures, machines, processes, circuits, buildings, equipment or projects, and supervision of construction for the purpose of securing compliance with specifications and design for any such work.

The Act also defines at considerable length what constitutes Professional and Civil Engineering and tells quite specifically what civil engineers may or may not do. Chemical engineers, electrical engineers, mechanical engineers, and petroleum engineers without registration may not legally use the title Professional Engineer or the other titles just mentioned. Notwithstanding all the definitions of engineering and descriptions of professional engineering set forth in the Act, drawing a sharp line between what is and what is not professional engineering is very difficult. California-registered Professional Engineers must be engineers with 6 years of qualifying experience acceptable to the Board and must have a knowledge of the basic fundamentals of science and mathematics upon which engineering is based. Also, evidence of ability to use these fundamentals in engineering must usually include experience in the design of engineering works rather than simply operation experience. One does not consider automobile drivers as automobile engineers. The word "design," of course, is used in its broad sense and not in the sense of being limited as a definition that indicates only making drawings and computations.

Our study of the status of the Professional Engineer does not indicate that the engineering profession is to any considerable degree deficient in proper standards, but no doubt all of us are of one accord in agreeing that the top standard has not been reached. Indeed, if that were so then probably there would be no need for a registration law.

Engineers are aiming toward perfection but when all problems have been solved in the best possible manner there will be no more engineering.

The opening paragraph refers to the public's poor understanding of the meaning of the term "Professional Engineering." Some persons indeed see no difference between an elevator operator and the designer of all of the intricate mechanisms that go into an automatic elevator to provide good and safe operation. We all know that the word "engineer" is probably misused more than any other word unless, perchance, it be the title "Doctor." Physicians have educated the public to distinguish between medical doctors and other types of doctors by the use of the letters M.D. after their names. Perhaps engineers should emphasize a program of using titles such as John Doe, P.E., unless some better name for professional engineering can be developed.

Raising the status of the Professional Engineer may cause some persons to think engineers should aim definitely to raise their personal incomes. A 1938 AIEE paper[1] showed that lawyers and doctors, thought by many engineers to be very highly paid, had take-home incomes after the deduction of office and other operating expenses that were in general no better than those of the engineers of equal standing. Conditions for engineers are probably equally favorable at the present time. Certainly if engineers consider themselves entitled to professional standards the salary status should not be raised by group-forced barter but rather should be determined by the demand for engineers known for high efficiency and expert knowledge. Perhaps men doing routine work sometimes called engineering, such as drafting and other subengineering work, should use an organized group barter plan as a last resort.

SUBSTANDARD REGISTERED PROFESSIONAL ENGINEERS

PASSING THE required registration examination in no way determines the grading of engineers but simply furnishes evidence that the registrant meets certain minimum requirements. This is, of course, as it should be. Then comes the question: How "stiff" should the examination be? In California the only way to qualify for registration is by examination. California law has no reciprocal provision which automatically gives registered professional engineers in other states California registration upon application. Establishing and maintaining a standard for these examinations is no easy matter. The men to be examined naturally have practiced in many fields; thus, a fair examination can be only a general one with probably a few options for the benefit of specialists. Also, it should deal to considerable extent with fundamentals considered by many college work. Students are no longer taught that physics courses must be passed and then forgotten.

There are many activities tending to reduce or tear down the rigor of the examination. Some of these are the desire of other State Boards to have their registrants recognized in a reciprocal procedure. If all states gave equally rigorous examinations, that would be ideal. The fact that they do not is probably not due to laxity on the part of the State Boards but rather is due to popular opinion, pressure from not-to-well-qualified persons who want registration, and political expediency factors that legislatures introduce into registration acts. Some state acts are so weak that persons may obtain registration merely by reporting evidence of experience. In some states registration may be obtained simply by graduation from an engineering college. There is the pressure of semi-engineers who are good salesmen but carry on only limited engineering activities and think the tone of the examinations should be reduced to a standard suitable to the training of such men. Unfortunately, there are still many older men educated as engineers who now are high-class repairmen, electricians, or technicians of ability but who do not realize that engineering today is not what it was 50 or perhaps even 30 years ago and are thus unable to distinguish between true engineering and technician abilities. Most registration examinations demand a rather high level of engineering experience and ability for passing. There has been some desire for uniform examinations for the entire country. Such examinations of course would have to be the resultant of many opinions and thus certainly would not be the rigorous examination desired by some states but would be compromise examinations. In addition, the mechanics of trying to give throughout the nation a stated examination at one particular date would be difficult. Arranging a common time for only four or five places in one state is often difficult.

There are still many engineers who have been admitted under grandfather clauses which, of course, must not be too restrictive but which in some states have been so lax as to permit practically anyone and everyone so desiring to register as an engineer. Indeed, there are persons in California who declare that such provision was made by the California grandfather clause whereas actually the grandfather clause in California simply gave the Board the right to register without examination men who in their opinion were qualified to pass a registration examination.

Are there too many registered professional engineers? Reference to the tables shows that chemical engineers in California have a professional registration of nearly three times the California membership of the Chemical Engineering Society. The registered civil engineers number $2^1/_2$ times the members of the American Society of Civil Engineers in the state. The electrical engineers have almost an even number of registrants and AIEE members, the number of registrants being 4,900 and the professional society members approximately 4,000. However, there are many registered professional engineers in the electrical engineering field who are not members of the AIEE or the Institute of Radio Engineers. The mechanical engineers have about twice as many registered engineers in California as members of The Society of Mechanical Engineers. No similar statistics are available for petroleum engineers because their membership is in an organization that includes mining and metallurgical engineers. These data indicate that too many engineers are neglecting the opportunities incidental to membership in the professional societies. Perhaps if that were not so and the professional society classifications were rigorously observed the practice of using professional society membership as a gauge of professional ability, which has been advocated by some professions, would be satisfactory. At present, however, there are very little data of value in this respect and there is no legal status as a professional engineer by virtue of membership in professional societies.

Professional engineering is a progressive science demanding that the status of the profession be raised apace with man's ever-expanding knowledge of nature's laws.

Engineers must study continually during their engineering activity to keep pace with the many channels in which engineering has developed. Indeed, it is difficult for specialists to keep up with their own special subdivisions of engineering. The progressiveness of engineering is proved by hundreds of examples. A simple one is induction motor design. A 40-horsepower motor is now made on the same frame that only 10 years ago was considered proper for only 30 horsepower, and 40 years ago that

frame was used for motors of only 10 horsepower. The power now developed by a frame is four times what was once good practice. Electronics and intriguing programs being opened by the new computing machines, sometimes called "thinking machines," and the present indicated new ways and means to use atomic energy far beyond the combustion uses with which we are now familiar are awe-inspiring in their prophesy for new fields of endeavor.

If engineers must keep pace with an expanding program, is it necessary that the time spent in college be increased, and if so, how shall that time be used? This subject also is one that this article touches only lightly but it is not difficult to suspect that sometime in the not too distant future there will be a stronger trend toward making engineering colleges truly graduate colleges just as are law and medical colleges. Already a few colleges require 5 years of work for a bachelor's degree and a large number of colleges are introducing expanding graduate work in engineering. The apparent advantages of much that has been done in this direction are not altogether real advantages because so many graduate curricula do not increase the analytical power of young engineers but serve only to delay their entrance into industry.

Unfortunately, not all colleges that are trying to carry on graduate work are properly financed or staffed for that work, and indeed some of them that are properly financed and provided with large faculties have very doubtful ideas as to what should constitute graduate engineering work. Undergraduate curricula are carefully inspected and accredited by Engineers' Council for Professional Development (ECPD), but no plan for graduate curricula accrediting seems feasible. These inspections have been of great value in improving engineering education. A set of standard engineering curricula common to engineering colleges is highly undesirable but even ECPD reports show that in some cases too much emphasis is placed upon conforming to certain curricula patterns, some of which differ too little from the technical institute curricula of today rather than being examples of a scientific standard which should mark and motivate professional engineering. This situation is not an illogical one because many technical institutes now give courses which equal engineering courses of 40 years ago, and indeed often equal some present college curricula. The great demand for engineers almost up to the time of World War II was for operating and construction engineers rather than for analytical engineers able to solve the expanding and increasingly complex problems, examples of which are those presented by our great power networks, the aircraft industry, to say nothing of guided missiles, atomic fission, and so forth. Fortunately, many engineering colleges are meeting today's challenge but there are some that still do not have a proper vision of modern and future engineering. There are still some engineering colleges content with no mathematics for engineers beyond the old type of sophomore integral calculus given in the manner in vogue a generation back. Faculties with such limited vision are inclined to think that graduate work in engineering means simply an expansion of the undergraduate pattern which has prevailed for 3/4 of a century; namely, a pattern based on training men for the routine methods of American operation and mass production.

The great pioneer astronomer, the late Dr. George E. Hale, had the true vision of the education needed by scientists and engineers. He had his vision reduced to operation when he accepted membership on the Board of Trustees of Throop Polytechnic Institute in 1908. He initiated what has become the California Institute of Technology pattern of technical education. That program calls for closely related undergraduate and graduate curricula in a college as far as possible free from the ills caused by sharp departmental lines. Its engineering curricula all include a large measure of scientific courses, presenting as much as possible a work aspect that tends to develop research and analytical skill rather than a knowledge of how to apply standard engineering handbook practice. He also prescribed a deviation from the then standard engineering curricula by insisting that 1/5 to 1/4 of all undergraduate curricula be allotted to humanistic studies. This does not mean that the older types of curricula are wholly unsuitable for the training of engineers. They have a place but they cannot long continue to produce highly qualified professional engineers. Engineers who wish to see the professional engineers' status keep pace with the art and science of engineering must exert every effort to see that graduate college programs provide the type of training that enables graduate engineers to be well acquainted with phases of chemistry, mathematics, and physics not taught in undergraduate courses. Engineers must also urge industry more widely to provide the young engineers in its employ with postcollege training courses that will develop men who can think clearly in a realm of the advanced sciences broader than those of their own particular industry.

PROFESSIONAL STANDARDS

We are facing a particular hazard at this time with regard to the maintenanee of high professional standards: the demand for engineers which greatly exceeds supply. The consequent recruiting of men trained at a lower level to do specific engineering or limited technical jobs under the title of engineer will cause many men with good knowledge in some very limited engineering field to think they are professional engineers and entitled to registration, whereas, actually, only a few men who have had such limited experience will have both the ability and fortitude to become engineers by the difficult route of self-study. Indeed, Boards of Registration have already had considerable difficulty of this type, largely with state agencies that operate under the ruling that only registered engineers may get salary increases or promotions. This ruling at first glance seems sound but for many individuals it becomes a serious matter because the men involved, though classified as engineers, are not engineers nor are they doing engineering work. The true situation is that capable men should be given titles describing the work they actually do rather than being classified as engineers. One should think improper titles could readily be changed but there is the rub: the persons operating the agencies in question do not want the titles changed; they want the

Boards to find some dodge for registering the individuals involved as professional engineers. Thus, we find a few state agencies that shout loudly for high-quality work and advocate civil service examinations as a means of getting that quality also working to weaken and in some cases almost trying to tear down present Board standards for registration.

Perhaps the invention pace is about all the human race can stand. While we in no way encourage technocracy, we are decidedly of the opinion that engineers will just now probably do more for mankind by increasing their efforts to make economic and social conditions keep up with the present development pace of engineering and science rather than attempting to increase that pace.

The "Canons of Ethics for Engineers," published by the ECPD, if thoroughly followed will guarantee a high professional standard. It opens with the Forward:

> Honesty, justice, and courtesy form a moral philosophy which, associated with mutual interest among men, constitutes the foundation of ethics. The engineer should recognize such a standard, not in passive observance, but as a set of dynamic principles guiding his conduct and way of life. It is his duty to practice his profession according to these Canons of Ethics.
>
> As the keystone of professional conduct is integrity, the engineer will discharge his duties with fidelity to the public, his employers, and clients, and with fairness and impartiality to all. It is his duty to interest himself in public welfare, and to be ready to apply his special knowledge for the benefit of mankind. He should uphold the honor and dignity of his profession and also avoid association with any enterprise of questionable character. In his dealings with fellow engineers he should be fair and tolerant.

That Forward is followed by 28 sections or paragraphs describing conduct under such headings as "Professional Life," "Relations With the Public," "Relations With Clients and Employees," and "Relations With Engineers."

The first engineer, Imhotep, we claim as such because it was his imagination that designed the Step Pyramid and saw it built 5,000 years ago. Thales, the first recorded electrical engineer, experimented with electricity 2,500 years ago. After a long period of inactivity there were engineers to build the Roman Empire's engineering wonders, and the Renaissance period produced Leonardo da Vinci, whose recently discovered writings describe many engineering conceptions not reduced to practice until centuries later. All of us are familiar with pioneer works associated with such names as Franklin, Faraday, Henry, Maxwell, Ohm, Volta, and Watt, and we pay tribute to men we have seen and heard such as Edison, Steinmetz, Lamme, De Forrest, and a whole multitude of others too numerous to name who have been leaders in the engineering of our day.

Dr. S. Ramo's recent epoch-making address entitled "Synthetic Intelligence," described to us so well the possibilities of super-computers—devices that make the slide rules and the calculating machines used so much during the first half of this century appear extremely simple and inadequate. Some writers have called these super-computers "mechanical brains" and conveyed the idea that they will do all of man's thinking. They are, however, only mental levers, or, in electrical terms, amplifiers for man's thinking. They cannot originate thoughts, they can only increase the speed and power of his thinking even as mechanical levers have changed hand production to production-line production and multiplied in other ways the muscular functioning of men. The best of the computing machines that have so far been conceived or even dreamed of cannot create or formulate the problems to be solved but must have those problems fed into them by master minds that know how to state problems properly and substitute electrical quantities for mechanical entities. As we ponder these thoughts we may well say there is no shortage of goals at which engineers may aim.

The engineer's lack of general culture was a fair complaint two score years ago but by and large there has been a definite improvement in the interest engineers have in being men of culture as well as men of technical ability. Indeed, this very interest is germinating an idea that science and engineering studies, though different from the study of Latin and Greek, may go far toward producing men of recognized culture. Probably most engineers will agree that excessive interest in techniques has caused them to neglect nontechnical community welfare problems.

THE ENGINEER'S RESPONSIBILITY

Engineers have a great responsibility which they probably have not fully realized. No other education or practice equals the study of science and engineering for teaching absolute honesty. Every scientist and engineer knows there can be no deviation from truth in the operation of nature's laws. They have impressed upon them throughout their entire careers the fact that mathematics and scientific data permit no statements that cannot be checked. These lessons, which are basic to a high level of living for individuals, communities, and nations, engineers must, if true to the profession, not only demonstrate by the manner in which they live but they must also enhance their value by applying them through active participation in civic and community affairs.

Participation with many examining boards charged with conducting personal interviews with candidates for positions of great engineering and executive responsibility has given the author great respect for the large proportion of the successful candidates for those positions who are not graduates of engineering colleges and often not graduates of any college. While these men seldom show the full comprehension of the technical work shown by the college graduates, they have enough technical knowledge to do the work and they have learned to know men. That knowledge seems largely to have been acquired by participation in Boy Scouts, YMCA, church, and civic activities. The engineers who have thus combined engineering with other service activities have not only bettered rather directly all of their fellowmen, but have also greatly enriched their own lives.

Engineers at present are held in high repute because they have effectively solved technical defense problems.

This places them in good positions to be captains as well as crewmen if they are willing to accept captains' responsibilities. Their discoveries of how to make gas turbines, guided missiles, atomic bombs, computing machines, and transistors should produce ways to discover solutions to the larger problem of having people get along better with each other.

Young engineers should be encouraged to increase their scope of activities. More engineers are needed in government-policy-forming and administrative positions. When recognized as professional men, more will be urged to occupy those positions. When urged, they should accept. Memory indicates there are few engineers in Congress, perhaps only three: Congressman Hinshaw and Senators Malone of Nevada and Flanders of Vermont. Flanders in particular is an example to be followed. His record in "Who's Who" shows him as engineer, president of large manufacturing companies, bank director, and the doer of many things that have earned for him the doctorate title and have made him a respected leader in government affairs.

California engineers can immediately help raise the California status by considering the advisability of requiring 8 years' experience rather than 6 for registration. That regulation, without being more severe than the present one, could help the Board a great deal. They can persuade engineers to stop publishing small disagreements with each other, a trait which seems to have grown out of training in precision methods. They can see to it that pressure groups do not weaken the present registration laws. If subelectrical engineers need registration, men who plan wiring and lighting of buildings should function in a way similar to that applied to land surveyors in relation to civil engineers.

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Electric Home Appliances—100 Years

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Today the list of electrically operated appliances for use in the home includes an appliance for about every purpose that requires heat or mechanical power. Inventors began to suggest useful applications of electricity for the home 100 years ago.

ELECTRICITY IS truly a servant in the house. It enables the homemaker to perform a multitude of tasks in the care of her home and family that would have needed the help of a corps of human servants in the "good old days." Electricity preserves, prepares, and cooks food and disposes of garbage wastes. It pumps and heats water and washes dishes. It removes dust, dirt, and lint from carpets, upholstery, and draperies. It heats, cools, and ventilates rooms. It washes, wrings, dries, and irons clothes. It tells time, rings door bells, and shaves the master of the house. It reduces drudgery, saves food and other materials, and produces better results.

Believe it or not, 100 years ago some people had begun to dream of the useful tasks that electricity might perform in the home. An inventor in Europe had obtained a patent on an electric toaster in 1850. It used platinum wire for the heating element. The only source of electric current that he knew was that obtainable from a wet battery. Magnetoelectric machines had been made but used only for a few purposes like arc lamps. Inquisitive inventors were busy studying electricity and had begun to suggest all kinds of useful applications.

By 1862 the commutator had been added to the magnetoelectric machine so as to provide direct current which up to that time had been provided only by batteries.

By 1872 this machine had been modified into the type that is the basis of all modern electric generators. Many improvements in arc lights, arc furnaces, and other applications of electric power were made during the previous 10 years.

The decade from 1872 to 1882 saw the birth of the modern electrical age. A practical incandescent lamp was perfected and a system of generating and distributing electric current at a constant voltage to operate a multitude of such lamps in parallel was developed and put into commercial operation.

From 1882 to 1892 progress was rapid. The a-c system of generation, transmission, and distribution was put into practical operation with all the auxiliary equipment needed to regulate and control the flow of energy to lamps, motors, heaters, and other apparatus. Electricity was becoming available over an ever-expanding area. Experimental models of many electrically heated and motor-operated

Full text of a paper, "Electric Home Appliances—100 Years," presented as part of the AIEE program at the Centennial of Engineering, Chicago, Ill., September 10–12, 1952.

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appliances for the home were made and tried out. Many of them, such as flatirons, hot plates, air heaters, ovens, tea kettles, and sewing machine motors, appeared on the market.

The first paper presented before the AIEE on a subject related to home appliances was one entitled "The Practical Requirements of Small Motors" by S. S. Wheeler on February 6, 1887,[1] in which he foresaw the great convenience to the housewife of a sewing machine on which she does not have to work the foot treadle continuously.

Between 1892 and 1902 a tremendous amount of study was devoted to appliances for the home. A patent on the heating pad was issued in 1892 and a second patent in 1894. A complete electric kitchen was displayed at the world's Columbian Exposition in Chicago, Ill., in 1893. Individual exhibitors showed many electrically heated and motor-operated appliances for the home.

Electric power companies had been operating their generators only at night because lighting had been their only load. Now many began to run continuously in order to build up a load in the daytime too. This provided the opportunity for the use of electric appliances in the home and inventors and manufacturers were busy bringing out new appliances and improving existing models.

The cost of cooking and performing other operations by electricity was investigated by many people. John Price Jackson presented a paper entitled "The Economy and Utility of Electric Cooking Appliances" before a meeting of the AIEE at Eliot, Maine, on July 28, 1897.[2] He reported data on numerous tests on appliances in actual use and compared the cost of cooking various meals with the cost of cooking the same with other fuels. He attempted to evaluate the convenience and comfort of electrical cooking compared to that performed with other fuels. He pointed out that the users of flatirons and of several other appliances appreciated them so much that the cost of the electricity to operate them was considered to be of little importance. It is interesting to note that his electric power was costing 10 cents per kilowatt-hour, a rate which would be considered very high today in spite of the inflation that has occurred during the intervening 55 years. (The average cost of electricity to the home in the year 1950 is reported in the January 1952 issue of *Electrical World* to have been 2.88 cents per kilowatt-hour.)

By 1902, 50 years ago, 24-hour service by the electric power companies had become quite common throughout the United States. Almost all cities and towns had electrical service and lines were being extended out into the country.

INCREASE IN SALES OF APPLIANCES

Electric appliances were being sold in larger quantities by 1902. For example, in the *Proceedings* of the National Electric Light Association (NELA) for 1903, we find the Committee on Progress reporting that one manufacturing company had sold 1,000 chafing dishes during the previous year and that it had sold a total of 6,000 flatirons since it had been in business. The production of other manufacturers was not reported. Some power companies did not welcome electric cooking appliances on their lines because they feared they would add to load on the system at the peak of the lighting load and require added investment in plant without providing additional revenue to compensate for it. This was a reasonable problem to consider and during the following years much study was given to such types of load; eventually it became a question of the kind of rate to charge that would encourage the homemaker to use electric appliances.

Development of new appliances and improvements in older appliances proceeded at a rapid pace. Although Herbert Booth in England in 1901 and David T. Kenney in the United States in 1902 had invented the vacuum cleaner, it remained for Hamilton to produce the high-speed motor which makes the lightweight efficient vacuum cleaner suitable for use in the home. Much research into the mechanics of cleaning carpets and other fabrics had been necessary before the convenience and efficiency of the present-day product was reached.

About 1902 the tantalum filament electric incandescent lamp was perfected and active work was in progress on the tungsten filament which was to have a profound effect on the market for household electric appliances.

In the *Proceedings* of NELA for 1904 there is a paper by J. I. Ayer discussing the power required to operate various appliances and the probable effect on the load of a central station. He mentioned the following appliances as being available in the market:

Sewing machine
Fan
Hair curler (50 watts)
Heating pad (50 watts)
Flatiron—for sewing room (200 to 300 watts)
Flatiron—for laundry (500 watts)
Tea kettle
Hot plate—for hot water for shaving or baby milk bottle (200 watts)
Chafing dish—(200 to 500 watts)
Coffee maker—(200 to 400 watts)

He suggested a panelboard in the kitchen into which several cooking appliances could be plugged for cooking meals. For this kitchen operation he suggested the following:

Oven	Disk stove with utensils to fit
Broiler or griddle	Water heater
Waffle iron	Plate warmer

Materials available for the heating elements in these appliances would not resist corrosion or oxidation. Usually it was necessary to embed the resistor in enamel or cement or clamp it between sheets of mica. Because the temperature of the resistance element must be kept low, the input into the appliance often was not sufficient for satisfactory performance. In spite of that handicap many users were pleased and the business was growing.

In 1905 a committee headed by J. I. Ayer reported to the NELA convention that it had sent questionnaires to 480 power companies and of the 231 who replied only 112 companies had household electrically heated appliances on their lines and only 93 reported that they were attempting to sell such appliances.

It is interesting to note the retail prices of certain appliances which were mentioned during the discussion of his report.

Chafing dish	$11.00 to $21.50
Waffle iron	$ 7.50 to $18.00
Flatiron	$ 5.00

In 1906 two developments occurred which were to exert an influence on the heating apparatus industry, and especially on household electric appliances.

The first development was the practical production of ductile tungsten for filaments for electric lamps. The then standard carbon filament lamp used 3.5 watts per candle power. The tungsten filament lamp used only 1.0 to 1.25 watts per candle power, the same amount of light from one-third the current. Consternation spread among the managers and owners of the electric power companies because they thought they could foresee a serious decline in the sale of electricity for lighting which at that time was almost the only source of revenue for many of them.

The second development was the invention of the nickel-chromium resistance material for electric heaters announced in a patent issued to A. L. Marsh on February 6, 1906. This material possesses the qualities that were especially needed to produce electrically heated appliances with the performance characteristics and durability that would be satisfactory to the homemaker.

The tungsten lamp stimulated the power companies to go after the home appliance load and the nickel-chromium resistance material made it possible for the manufacturers to produce electrically heated appliances that would meet the requirements.

PERIOD OF EXPANDED ACTIVITY

The period of 1902 to 1912 was one of the tremendous expansion of activity in experimentation and invention of all types of household electric appliances. Electric ranges were made by applying electric heaters in place of gas burners. Fireless cookers were equipped with electric heaters. Immersion heaters were made to apply to hot water tanks in place of gas heaters. Flatirons, toasters, table stoves, air heaters, radiators, and many other appliances appeared in new designs.

Development of motor-operated appliances became very active. Fans more suited to the home made their appearance. Clothes washers were designed to take advantage of the improved designs of motors. Much study was given to the problem of producing a small refrigerator suitable for use in the home. The fundamentals of mechanical refrigeration were well understood because it had been under investigation for more than 100 years and commercial applications for making ice, freezing food, and other purposes had become well established all over the world.

During the next 10 years, 1912 to 1922, progress was interrupted for a time by World War I. The electric range became firmly established. In a book entitled "Electric Heating," by E. A. Wilcox, published about 1916, 12 manufacturers are mentioned who advertised a total of 95 different models of electric ranges.

It had been recognized that too many homes had no place into which to plug an appliance except a lampholder and that often was not accessible. An industry-wide campaign was started to persuade home builders and home owners to install appliance receptacles at convenient locations on the wall or along the baseboard of every room. This campaign is being continued to this day under the supervision of the National Adequate Wiring Bureau.

Too many different designs of attachment plugs presented a nuisance that was corrected by standardization on the familiar parallel-blade type of plug and corresponding receptacle which today is used throughout the country.

Another movement started at this time was an effort to standardize the voltage at the outlet. Because of the wide variation in voltage in different parts of the country, and even in different parts of the same city, the manufacturers were required to make home appliances in three or more voltages in the range from 95 to 125 volts. Although it took many years to bring it about, the adoption of 120 volts as the "Preferred Voltage" at the outlet in each home has greatly simplified the problem of manufacturing, distributing and servicing household appliances. As a result, we have reached the time when a family can move its electric appliances into a new home in any part of the country and they can be used without alteration on the electricity there.

The years 1922 to 1932 saw tremendous improvement in the performance, convenience, and appearance of all home electric appliances. The thermostat was built into the flatiron, beginning with the bimetal disk type. Automatic temperature regulation reduced the fire hazard, permitted an increase in the wattage input, and resulted in better and faster ironing. A later development was an arrangement for adjusting the temperature maintained by the thermostat and a reduction in the total weight of an iron, still further increasing convenience and reducing effort.

Better thermostats became available for ovens, roasters, water heaters, and other appliances. Devices to control the time of operation of ovens on ranges were improved and a toaster became available that had a timer which turned the current off and ejected the bread when properly toasted. Coffee makers of the vacuum type became popular and not only started active development of new types of coffee makers but stimulated the consumption of coffee because of the improved quality of the beverage.

APPLIANCES ACCEPTED AS HOME NECESSITIES

By 1932 the household electric appliances had proved their worth to the homemakers and had been accepted as necessary equipment for the home. Competition among the many hundreds of manufacturers, each striving to supply better appliances than his competitors, resulted in a continuous stream of new ideas both for appliances to render a new service and for improvements in the older appliances.

For example, electrically heated bedcoverings in the form of blankets, sheets, and spreads were introduced and have become popular. In general, their electrical design followed the principles of the heating pads that had been in production for many years. The automatic clothes

washer was developed, one that was controlled by timers and thermostats in such a manner that the clothes in the machine were washed, rinsed, and dried to the proper degree of dampness without any attention from the housewife. The next step, of course, was an electrically operated clothes dryer. Thus we have a complete electric laundry for the home: washing, drying, ironing.

Resulting from the developments in electric refrigerators for the home, room coolers and dehumidifiers have been produced to provide greater comfort during the periods of hot weather which occur over large parts of the country. Cabinets for storing food in a frozen state are a real contribution toward economy. When food is available from the kitchen garden or from the market at the lowest price of the season, the freezer is filled and the family has a supply for the winter months when similar fresh foods are very expensive or not available.

The food waste disposer, or garbage grinder, has been added to the kitchen equipment. Food wastes are ground into small particles and flushed down into the sewer as they occur, thus avoiding an unsanitary accumulation of such material in the trash can.

Electric motors drive pumps on farms to provide fresh water from the wells at all times wherever needed in the house or barns. Electrically heated storage water heaters automatically maintain the desired temperature in town or country. And we must not forget the electric shaver, a boon to millions of men with beards the ordinary razor never conquers.

Today, in this year of 1952, the list of electrically operated appliances available for use in the home includes an appliance for almost every purpose that requires heat or mechanical power. Following is a list containing most of these appliances and the percentage of the wired homes in which it is estimated they may be found at this time (from *Electrical Merchandising*, January 1952):

	Percentage of Wired Homes
Air conditioners, room unit type	0.8
Bedcoverings	7.1
Blenders (drink mixers)	2.6
Cleaners, vacuum	57.7
Clocks	78.8
Coffee makers	49.0
Dish washers	2.6
Food waste disposers	2.7
Freezers, home	9.3
Space heaters, radiant and convection	22.2
Heating pads	29.9
Hot plates	20.8
Irons	90.0
Mixers, food	27.9
Ranges	22.8
Refrigerators	86.7
Roasters	8.5
Shavers	30.0
Toasters	70.5
Washing machines, clothes	73.5
Water heaters, storage types	12.8

The wide use of electric appliances in the homes is attested by their steadily increasing consumption of electric power. It is reliably estimated that the average home in the United States used 1,825 kilowatt-hours of electric power during the year 1950, and the trend tends rapidly upwards.

Little published information is available about the development of many of the most useful appliances. A series of articles by T. F. Blackburn in *Electrical Merchandising* in November 1940, April 1941, March to August 1944, November 1944, December 1945 to August 1946, and July 1947 give much information about the histories of several appliances. The *Proceedings* of NELA, and more lately of the Edison Electric Institute, contain many reports of committees that studied the appliances as they came on the lines of the power companies. Some books have been published containing explanations of the products but with little historical data. Practically nothing has been published of a technical nature showing the meticulous care with which the engineers working on the designs of appliances have studied every detail of design and the characteristics of all the materials that must be used to produce successful appliances. This brief article could be only a general outline of the progress which has been made by those engineers.

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Einstein Theory May Be Verified

One of Einstein's theories about the sun and stars may be verified by measurements now being made on four large glass photographic plates at the Yale University Observatory, New Haven, Conn. The exacting work is being done by Professor George A. Van Biesbroeck, a member of the Yerkes Observatory staff at the University of Chicago, Ill., who is at Yale using its precision measuring engine, the largest one of its kind in the country.

Dr. Einstein in 1916 proposed that stars are not always where they seem to be because the gravitational pull of the sun bends starlight on its way to earth. As a result, an observer on earth sees the stars in an incorrect position in relation to the sun. Astronomers have not been satisfied with the many observations made to verify the theory. In many of these observations, a shift in starlight larger than predicted by Einstein has been noted.

Last February, Professor Van Biesbroeck went to Khartoum in Africa to photograph the eclipse of the sun, since an eclipse is the only time stars are visible around the sun. Then, 6 months later, in August, the astronomer went back to Khartoum to take a photograph of the night sky when the same stars appeared. He took two photographs on glass plates each time and then came to Yale to measure star positions on the plates by means of the engine. His computations probably will be completed within a few weeks, and his results may verify Einstein's theory.

Management of Engineering Work

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Management in its fundamental aspects is the same regardless of the kind of business enterprise. Effective management of engineering work is accomplished by applying the basic principles of the work of management to the work of engineering.

THE PRIMARY objective of engineering work is to make the properties of matter and sources of power in nature useful to man in structures, machines, and manufactured products. A person is prepared to do engineering work when he possesses knowledge of mathematics, physical and applied sciences, properties of materials, and the fundamental principles of engineering design.

The purpose of management in engineering work is to accomplish objectives on time, at reasonable cost, and with reasonable human effort. To do the management part of the work a person is prepared when he has a working knowledge of the social sciences, human relations, measurement of results including accounting, and the principles of management of men, materials, machines, time, and money.

PRINCIPLES OF MANAGEMENT OF ENGINEERING WORK

MANAGEMENT IN ITS fundamental aspects is the same regardless of the kind of business enterprise. The work can be classified under basic elements as in Figure 1. Thus, management is the administration of a business enterprise through leadership by planning, organizing, measuring, and co-ordinating. These last four words comprise the technical work of management. Leadership comprises the human part of the work which is getting people to act co-operatively by showing the way rather than by command.

The importance of each of the principal elements of management is seen readily. Each of us could find cases where engineering work has come short of what might have been accomplished because management has rested on a good plan and a fine organization, thinking it could not help but work and be successful. But some defect in co-ordinating caused a lack of co-ordination of the effort of the personnel and limited the success. In other cases, a defect in measuring caused a lack in prompt recording and appraisal of performance standards, results, and trends. Thus, action and leadership to guide the work properly has been erroneous or at least sluggish; and so over each operating period there has been limited success.

In cases where the defect is in planning, such as badly set objectives and poor forecasting, it is obvious that the enterprise will be in for trouble. When organizing allows burdensome or fuzzy assignments of authority or responsibility, too many bosses, jumbled relationships, poor placement of human and material resources, or indistinct accountability, trouble is equally sure to ensue.

Moreover, leadership that slips a bit on showing the way, or teaching, encouraging, stimulating, and motivating personnel is bound to cause the enterprise to fall short of full achievement.

EFFECTIVE MANAGEMENT OF ENGINEERING WORK

HERE, THE PURPOSE is to apply the basic principles of the work of management to accomplish effectively the work of engineering.

Planning. It is surprising to find, in some cases, only partial appreciation of the importance of determining clear objectives, including time schedules for their accomplishment, from thorough, careful investigation and analysis of pertinent facts and trends. This is the first step in planning as briefly outlined in Figure 1. The result of planning is to have determined what the job is, when it is to be done, what equipment, materials, and supplies will be required and what they will cost, what personnel will be required and the cost, what policies will be followed, and what standards of accomplishment are to be worked to. The objectives and standards must be practical and yet must be set high and difficult to attain.

Organizing. At this point, the author wants to emphasize that the elements of management work, leadership of an enterprise by planning, organizing, measuring, and co-ordinating, are done continuously and simultaneously and not in sequence, except perhaps in establishing a new business.

Organizing is an especially important part of the management of engineering work because it facilitates getting work done by others by the orderly arrangement of both individual and group efforts. The total work is divided into parts which can be handled effectively by individuals. This is done by analyzing the total work, classifying its details, and grouping like work together. In this way the work is divided so that responsibility for its performance can be assigned and authority delegated to individuals, starting at the top of the organization structure. Successive subdivisions of the work are made at each level of management down to and including the basic group supervisor and the individuals working under his guidance.

Revised text of conference paper recommended by the AIEE Committee on Management and presented at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952.

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The author is indebted to others for some of the ideas, charts, and tables. The thoughts are personal and should not be considered as management philosophy of the author's company.

MANAGEMENT

The Administration of a Business Enterprise Through Leadership* by Planning, Organizing, Measuring and Co-ordinating (or Integrating) Its Human and Material Resources.

LEADERSHIP*

Inspires, Encourages, Teaches, Stimulates, and Motivates Personnel to Perform Their Respective Jobs Voluntarily as an Integrated and Synchronized Group

Inspires and Encourages
- Initiative, Resourcefulness, and Proper Aggressiveness
- Friendly Co-operative Teamwork
- Mutual Respect and Loyalty

Teaches
- What Is to Be Done Where and Why
- How and When It Is to Be Done by Whom and Why
- Special Knowledge and Skills Co-operative Team Play

Stimulates
- Interests and Ambition
- Participation—A Sense of Belonging

Motivates Personnel Through
- Compensation and Incentives
- Recognition, Promotion, and Development
- Respect and Loyalty

PLANNING

Determines What Should Be Accomplished With the Human and Material Resources of the Enterprise.

Analysis and Formulation
- Analyzing the past, present conditions, and trends
- Foretelling the future
- Alternate possible action
- Comparing alternatives

Development and Determination of Basic
- Objectives
- Policies
- Plans
- Organization structure, functions, and key personnel requirements

Basic Plans as to:
- Machines
- Materials
- Men
- Money
- Industry position
- Return on investment
- Per cent income to sales
- Turnovers
- Standards of accountability

ORGANIZING

Determines How the Human and Material Resources of the Enterprise Are to Be Utilized.

Detailed Organization Structure and Functions
- Allocating and integrating objectives
- Determining necessary work to reach objectives
- Classifying and grouping related work
- Defining responsibility, authority, and accountability
- Defining relationships

Manning the Structure
- Selection
- Placement
- Development
- Promotion
- Compensation and incentives

Implementation of Basic Plans
- Programs
- Methods, procedures and, techniques
- Detailed standards (accountability)
- Machines
- Materials
- Men
- Money

MEASURING

Measurement Standards, Mechanism, and Analysis of Progress and Performance.

Measurement Standards converts established standards for each accountability into measurable terms of units, dollars, indexes, budgets, turnovers, time, and so forth

Measuring Mechanism
- Establishes measuring mechanism including media and agencies of control and analysis responsibility over six organic functions, work of management, and machines, materials, men, and money

Make results of analysis available for use by agency of control in planning, organizing, and integrating

CO-ORDINATING

Integrates and Synchronizes the Human Resources to Obtain Most Effective Utilization of Machines, Materials, Men, and Money—the resources of the business.

Reunites pieces of work assigned to individuals under the organization structure

Keeps work of individuals in balance as to nature and cost and timing

Teaches, advises, counsels as to facts to promote voluntary initative on a team which is an integrated, synchronized balanced unit

Achieves smooth flow (pace, turnover, and time) by respect for feelings, reaction, and productivity of individual

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To achieve, on time, challenging and difficult-to-attain objectives of the business in the balanced best interests of customers, suppliers, employees, and share owners.

Figure 1. The principal elements of management

Then with the work of each position and its relationships to each other position and to the whole job definitely established, and charted as for example in Figure 2, the organization structure is manned by placing qualified competent people in each position.

This procedure may be called the fundamental approach to the work of organizing. Like the fundamental approach to the solution of problems in engineering, it involves assumptions or premises which make the problem solvable but which must be checked for validity, usually by comparing the answer with observed facts.

In this case, the premise is that the available human resources will contain individuals whose qualifications, including their abilities, will fit the definite requirements of each position. This ideal situation may not be fully the case and, therefore, the organization structure arrived at by the fundamental approach may have to be modified in order to fit available individuals to the jobs which it sets up. This points up two things. First, that to try to arrive at an organization structure except by using the fundamental approach is to subject one's self to the hazards of the cut-and-try method including the likelihood that parts of the work will not get done. Furthermore, since the continuity of engineering work in the modern corporate enterprise exceeds the unknown period of individuals, it is desirable to keep the fundamental pattern of organization stable; otherwise, changes in jobs of individuals require shuffles that upset too many other people too often. Second, that it is important to develop people to meet the job requirements using a planned appraisal and development procedure in conjunction with established specifications for the man required for each position.

For organization, the work of engineering should be divided first into the fewest possible number of major parts which are clean-cut and do not overlap but which, taken together, comprise all of the work to be done. The major parts are similarly subdivided into parts and so on until all of the detail tasks to be done are accounted for. Classification and grouping of engineering work may be according to the following:

1. Type of product handled, for example, single-phase, polyphase, d-c, synchronous, aircraft, or marine motors.
2. Physical size of product handled, for example, small versus large motors.
3. Geographic area of operation.
4. Nature of technical work, that is, according to such classifications as development, design, and so forth.

Operating responsibility and authority should be placed far enough down in the organization to have it as close as feasible to where the action occurs. Then it will be applied with the most intimate and current understanding of the work about which decisions are being made. Responsibility for special services, that is, staff work, should be placed high enough in the organization to insure that specialists who have required talent and capability may perform this work on a full-time basis.

The check list given in Figure 3 may be helpful in organizing engineering work.

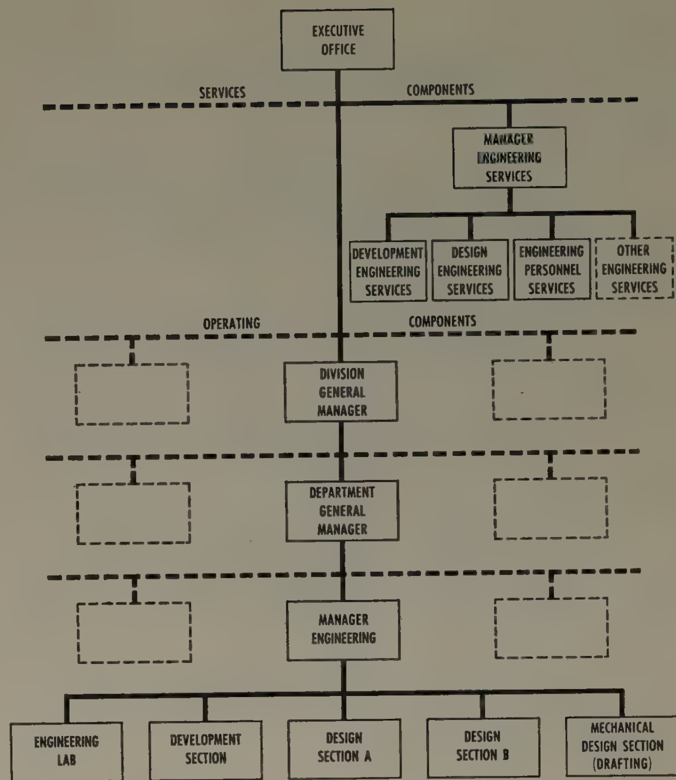

Figure 2. Organization structure showing services (staff) high in the structure. For small organizations the number of levels required in management will be less

Measuring. The third element in the management of engineering work is measuring. This is the process which measures, analyzes, and appraises progress and performance. This measurement is done against preset standards of performance.

The work of measuring is described briefly in Figure 1. In engineering work, some of the factors which can be measured against standards are, for example, routine operating expense, special expense as for development of new or improved products or special products, expense for maintenance and replacement of tools, expense for special patterns and tools, expense for services to users, and development and performance of personnel. Operating expense and expense for maintaining patterns and tools are generally variable in an $(A+By)$ formula where A and B are constants and y is the work load. Such a formula is essential to determine the break-even point for the business. Development expense is separate as this is an investment in the future and should be independent of current business volume. Expense for patterns and tools is governed heavily by engineering design and, to that extent, is an engineering expense. Measurement of development and performance of personnel is by no means last or least of the factors to be measured.

The last-mentioned factor indicates that measurement is broader than financial accounting, covering many key factors in performance, including statistical analysis for quality control, and even those broader areas of measuring which are being explored increasingly under such captions as "Operations Research," and "Cybernetics." Moreover, measurement is concerned with trends, rates of change, and increments of progress, as well as conditions

1. Is the organization built around the main functions and subfunctions of the business and not around an individual or group of individuals?

2. Are the functions and subfunctions, and their relationships, classified to promote balance in the organization and to avoid duplicating or overlapping functions, the neglect of essential functions, or the overemphasis of less essential functions?

3. Are management responsibilities and authority clearly defined so that the proper point of decision can be determined quickly?

4. Are responsibilities coupled with corresponding authority and is the statement of this authority and its scope as specific as possible?

5. Is the maximum practicable amount of authority delegated and placed as close as possible to the point where decision and action are required? This permits control and co-ordination to take place at as low a level in the organization as possible.

6. Is the organization structure such as to permit each member of management to exercise the maximum initiative and resourcefulness within the scope of his delegated authority?

7. To the maximum extent possible, are operating and line functions separated from service and staff functions and adequate but not excessive emphasis placed on important service and staff activities?

8. Is the organization flexible and capable of adjustment to changing external and internal conditions? The possibility of expansion or contraction, as business volume or economic or technical conditions fluctuate, should be inherent in the plan.

9. Does each member of management have an optimum number of major subordinates reporting directly to him—neither more than he can most effectively manage nor less than will fully utilize and challenge his management capabilities? Except at the first level of supervision, this span of control is usually most effective if limited to from six to nine direct management subordinates if their work involves either multitudinous or complex relationships.

10. Is the number of levels of authority kept at a minimum? The greater the number of management levels, the longer is the chain of command, the longer the time required for instructions and information to travel up and down within the organization and the greater the chance of error in communication.

11. Does each member in the organization know to whom he reports and who reports to him?

12. Does each member fully understand his own work, his relationships, and his accountability, so that he can carry fairly and accept full performance responsibility for his work, both as an individual and in the groups of which he is a natural part?

13. Does each member report to only one direct superior?

14. Is the organization structure as simple as possible; does it include only essential jobs?

Figure 3. Check list for use in organizing engineering work

at the close of intervals. The concept of measuring is broad, including, in addition to measurement, analysis, interpretation, appraisal, judgment, and decision. It goes to the basic idea that increasingly management may achieve results through the authority of fact and knowledge rather than by the nonprofessional exercise of authority of position, or command.

Co-ordinating. A fourth element of the work of management is co-ordinating, forming all of the work into one common action. This involves bringing together all of the operations, particularly the effort of all personnel to achieve co-operative teamwork, resulting in smooth, synchronized pace and flow of work. The manager of engineering sees to it first that the individuals reporting to him understand the objectives and plan, that they function in a clear organization structure and know the standards and measurement factors applicable to their work. Individually they then may perform voluntarily so that their respective portions of the over-all work are well done and smoothly fitted together in an environment which gives them satisfaction both in accomplishments and in mutual relationships.

The manager thus can see that the individuals have direct contacts with each other to gain understanding of one another and to exchange information directly. The direct contacts can be maintained frequently enough so that ideas affecting teamwork will not develop unilaterally to result in serious conflicts. Good communication up and down and crosswise among all individuals in the organization is essential. Good organization structure will provide for and facilitate good co-ordination, and thus will stimulate both venturesome personal effort and good, aggressive, competitive team play. Service specialists, working with all of the engineering heads, have a co-ordinating influence. Furthermore, the selection and development of people can be used to promote voluntary, co-operative, action.

Effective co-ordination is especially important in engineering work because it is here that group effort is required of professional people, a high proportion of whom may be unusually creative individuals. Moreover, engineers have organized professional societies, some to develop and regulate the practice of the art of engineering, others to govern the profession in the mutual interest of its members and the public. Thus, the engineer has a feeling of professional responsibility and individual importance. He realizes that he is a part of management, that technical decisions that he must make are determining factors in the success of the business.

The engineer is a specialist in the physical sciences and in machines. The young engineer coming out of college is prepared to be such a specialist and applies himself fully to this work. The manager specializes in the social sciences and in people. As the young engineer matures, his interests, talents, and knowledge may develop toward the work of management. Or his interests, talents, and knowledge may develop toward the eminence of scientific authority. Still again, he may develop toward distinction in purely creative work.

Engineering work needs all these kinds of talent working together. Thus, there should be opportunity unlimited for each individual to determine, and to pursue, his own predominant interests and best talents. The importance of unlimited opportunities along each path needs especially to be emphasized.

CONCLUSION

Looking ahead, the growth of engineering work, the increasing need for professional engineers, and the increasing demand for the fruits of engineering work, create a special need for the best possible—and most professional—management based on true principles and effective techniques.

Management problems need to be solved by the fundamental approach familiar to engineers for the solution of engineering problems.

This analysis has held that the fundamental work of all management consists of the exercise of leadership of an enterprise by planning, organizing, measuring, and coordinating the full use of all of the human and material resources. Leadership is the human part of the work, in contrast to the technical parts of the work, and is getting people to act by showing the way.

Success in the management of engineering work is built on these fundamental principles, on their clear understanding, and on their skillful and objective application to the work ahead and in hand.

The development of sound human relationships in engineering work is especially important. There should be opportunity for each individual to develop and to use his best talents and to find satisfying achievement and recognition in his particular contribution to the work of the group. With respect to the manager, the possession of warm, human qualities is fundamental to getting things done by people on a long-term basis.

Management of engineering work in accordance with the principles of management will achieve two things. First, it will accomplish more effectively the work of engineering, increasing its service to society, as well as to engineers themselves. Second, because the principles of management are more common than is realized for all kinds of enterprise, engineers as individuals will become better able to manage all kinds of human effort.

Welding in the Electrical Industry

J. HEUSCHKEL

Welding is discussed in terms of its historical perspective, various processes, materials, applications, research, educational aspects, and future prospects

One significant component of the industrial revolution which has been occurring during the past century was the discovery and exploitation of the fact that metallic subparts of engineering products and structures could be satisfactorily welded together on a mass production basis. The electrical industry has played a leading part in providing the necessary electric equipment and materials for use by all of industry for this purpose. It has adopted welding as the means for joining in most types of electric equipment. Electric generating, transmitting, and consuming equipment are today being fabricated by welding. Products ranging from giant generators to tiny elements of electric light bulbs depend upon welded joints for their successful performance. The application of welding within the electrical industry has reached the point where many electrical products are no better than the welds going into their manufacture. This has focused special attention upon the high quality requirements of the design of parts for welding, upon the selection and preparation of metals for welding, and upon the training of personnel, particularly mechanical engineering personnel engaged in the design and manufacture of electric equipment. It has imposed upon research the task of providing information leading towards better and more nearly foolproof means for the mass production welding of component parts. The present status of welding in the electrical industry is secure, but improvements may be anticipated for the continued maintenance of quality in that rapidly expanding industry.

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WELDING PROCESSES

The basic processes being used are of four broad types: brazing, arc, resistance, and gas welding. The classifications are based upon the mode of application of the filler metal and the applied form of heating. A perspective on the present status of welding may best be secured by briefly reviewing the outstanding features and the history of the development of the several processes. The ancients knew how to weld lead piping and other

simple parts. Even earlier applications of soft soldering are on record. Such procedures were confined to the usage of low-melting-point metals.

Welding is of European origin. The dynamo was introduced there in 1832. An electric arc drawn between a carbon and the metal was used for melting in 1865. Modern welding dates from that year.

The use of twin-carbon arc welding was proposed in 1874. Here the arc occurs between two carbon poles and the arc flame produces the fusing heat. Fifty years later tungsten was substituted for the carbons, a shield of hydrogen was introduced around the arc and the atomic hydrogen process was available.

The single-carbon arc welding process, involving an arc drawn between a carbon and the work, was developed in 1885. In modern practice tungsten has again been substituted for carbon; argon or helium shielding has been provided; a high-frequency arc-initiating mechanism has been added; and automatic feeding of filler metal has been provided, when desired.

Consumable bare electrodes were used for metal-arc welding in 1892. Here the electrode also furnished the source of the added metal through the medium of a metal transferring arc. The detrimental effects of the oxygen and nitrogen components of the air upon the weld deposits were early recognized; in fact the American, Coffin, patented a process of arc welding in nonoxidizing gaseous atmospheres in 1890. Flux-coated consumable electrodes to shield the arc were described in 1907. This was the forerunner of modern flux and gas shielded metal-arc welding. Mass-production extrusion techniques of improved formulations are the significant intervening changes. Granulated fluxes, which permit the use of bare wire with the arc operating under a molten flux blanket, were developed about 1930. Engineering ingenuity thus provided the practical solution to the welding problem by furnishing cheap mass-produced electrodes which have bridged the gap of time until inert or other suitable direct gaseous shields were economically available. Covered electrodes still form the basis for most metal-arc welding, although important usage is being made of granulated flux-covered arcs and the application of inert-gas-shielded consumable electrodes is growing rapidly.

Direct shielding by the use of inert gases, such as argon and helium, was investigated by research staffs of the American electrical industry in the 1920's and in spite of the prohibitive costs of those gases at that time, basic patents were secured. Production usage was retarded for another 20 years by the high cost of the inert gases. Native helium, now selling for one cent per cubic foot at the source, was a laboratory curiosity costing $2,500 per cubic foot as late as 1915. Welding grade helium is now a high purity gas, about 99.8 per cent helium. Argon of the same order of purity is also available, the commercial cost being competitive.

Either alternating or direct currents are being employed with the several arc-welding processes together with either manual or automatic manipulation of the arc. The story of the development of suitable electric equipment, which must meet both the complex electrical and mechanical requirements of the arc, while producing metallurgically and mechanically suitable results, is a subject in itself. Aggressive engineering first made possible and then applied suitable arc-welding machines and cheap covered electrodes. The ductility of the arc-deposited weld metal over that originally produced has been at least tripled while its strength has been increased.

A parallel series of developments has occurred in the electric-resistance-heating welding processes. Joule, in 1857, referred to the end butt welding of wires by the resistance heating effect. This heating technique was extended to joining of localized interfaces, that is, spot welding, and was promoted in America by Thomson in 1877. Electric equipment for that purpose was available in 1886. Percussion welding for making butt welds very rapidly, thus producing a narrow heat-affected zone, was invented by Chubb in 1908. Projection welding, the localized fusing of coined contact zones, was introduced in 1909. Flash welding, an accidental discovery, dates from 1910. In the same year resistance seam welding or continuously overlapped spotting was introduced. With each process, strong joints can be produced.

The development of the ignitron in the early 1930's and the invention by Dawson of the direct ignitron control for resistance welding placed resistance welding upon an accurately controlled time base. It then became possible to initiate and terminate the passage of high-magnitude currents to node-point accuracy. Since that time several forms of energy application have been devised with precision-built machines which permit the mass-production welding of such sensitive metals as aluminum alloys, for example, on a high quality basis. Again as with arc welding, the story of the detail developments of machines and controls which meet the exacting electrical-mechanical-metallurgical requirements is a story within itself. By projecting the past rate of change into the future, one may anticipate dramatic improvements to come. Resistance welding, in its several forms, already has become the means for rapid precise production of small parts in quantity.

About 1900 the exothermic oxygen-acetylene process was being developed. Since its use required little auxiliary equipment and no electric energy, it was widely applied during that period. Improvements led to the usage of multiple nozzles in automatic machines for manufacture of continuous tubing and many repeat production applications on small parts. Electric conductor wire ends are being cut and welded by this process. While electric-arc and resistance welding have pre-empted nearly all applications, the use of cutting gases to prepare parts for welding has so rapidly advanced that gas volumes consumed now are far higher than ever before. Natural and manufactured gases in combination with air recently have been added to the basic or primary combinations of oxygen-acetylene as heating and joining mediums.

By 1895 Goldschmidt had discovered the exothermic chemical reactions which takes place between finely divided metals such as aluminum, and the oxides of metals having a lesser affinity for oxygen, such as iron. This principle applied to welding completed the basic process discoveries.

During the years the term brazing has been assigned to that group of processes, regardless of heat source, wherein a molten filler metal is used with a melting point lower than that of the base metal but over 800 degrees Fahrenheit and its entry into the joint is by capillary action.

The term soldering is applied to filler metals melting below 800 degrees Fahrenheit. Soldering is not considered to be a welding process, but this metals-joining method is widely used particularly for electrical connections.

It remained for the contingencies of three military situations to dramatize publicly the value of welding. In 1917 the engines of captured German ships were presumably wrecked by their stubborn crews before capture, only to be repaired and quickly restored to seagoing condition by the use of electric arc welding under the supervision of American engineers. The second public impetus occurred as an aftermath of the same conflict. Imposed restrictions on ship tonnage were partially circumvented by the German Navy through the ingenious use of welding to reduce hull weight. The displacement savings were transferred to both added propulsive power and ordnance. The United States Navy later profited by that example. These lessons of weight saving through welding were not overlooked by industry. The third military-actuated expansion in the use of welding occurred under emergency conditions in 1941. America was suddenly engulfed in all-out war. Machine tools were inadequate. Production was increased at unheard-of rates. Tanks, aircraft, ships, and other tools of war were required in unprecedented quantities. For this effort engineering used welding as the only practical metals-joining method. Armor was arc welded. Aircraft components were spot welded. Spot-welding machines and controls were rapidly modified and perfected to the point where, for example, aluminum alloys were fabricated in mass production to aircraft quality requirements. Only 20 years earlier those same metals were considered to be unweldable. The achieved results were brought about by improvements effected in the electric circuitry, transformers, and controls, combined with a better understanding and handling of the contact problem. Further improvements are under way.

DESIGN

It is not adequate in the design of fabricated parts simply to choose between manufacture by welded or nonwelded procedures. When selecting welding as the manufacturing method, prewelded-part edge configuration, the procedure for preparation of parts, part tolerances, handling methods, positioning, and jigging techniques which result in the best product at the lowest cost must be selected before the metal is ordered. Choice of selection between the several existing welding processes is becoming more and more involved. The engineer must meet this challenge. Each metal-product-process combination requires that the components be designed for usage with the selected process to provide the product service requirements. Costly production difficulties from improper design must be avoided.

In domestic appliances: the electric range, the light bulb, the refrigerator; in transport: the electric trains and trolleys, the spark plugs and generator components of the combustion engines of automobile, airplane, and watercraft; in the field of personal comfort: the cold-drink dispenser, the fan, the air conditioner; in communications: the telephone, telegraph, radio, and television; in fact wherever electricity is employed to increase the ease and comfort of modern living, the design of the device includes, in proportionate part, the requirements of the welding process to be used in its manufacture. This means that each metallic part must be properly selected and proportioned in advance. Thus welding has had an enormous impact upon the intellectual needs of the electrical industry. Key personnel must know the proper answers in advance or must secure them. There is no room for production trial-and-error procedures. Fortunately the many designs involved reduce to a usable number of combinations of joints which are suitable for use under different conditions with each of the several processes.

MATERIALS

This is also the age of metals. The industrial transition from riveting and bolting to welded construction has strongly accentuated the importance of the metallurgical reactions of the metals to heat. It made little difference under riveted procedures whether there was a substantial variation in carbon, manganese, or sulphur content of a steel, for example. When welding, such transient variations in the wrong direction are disastrous. Metals, designed for specific applications of strength at some temperature level, or of resistance to corrosion in some particular medium, may not have suitable reactions to the application of the thermal-stress cycle which accompanies the welding action. The widespread adoption of welding has come about following the devising of the several processes which tend to correct for the natural reaction between metals and the air-component gases, oxygen and nitrogen, at the high welding temperatures. Also, the form of application of energy was adapted to suit conditions where narrow plastic ranges existed in low-melting-point metals, such as aluminum, or where tempering was required, as for steels of medium carbon content. But all the adjusting has not been possible from the process variations alone. The design of metals for welding has become an important consideration.

Metals being welded within the electrical industry include silver in contacts; copper and aluminum in conductors; magnetic materials; the high-temperature alloys; the high melting point metals, tungsten, molybdenum, and tantalum; the light alloys of magnesium, titanium and aluminum; and the common and prosaic but widely used structural material, carbon steel.

Welded joints in products of the industry are subject to many types of service involving both high and low temperatures, high and low electrical resistivity, varying degrees of corrosion, and different types and magnitudes of stress. Either high or low electrical resistivity may be required. With the many metals involved, we have here the entire gamut of conditions.

The industry is therefore materials minded. Materials, engineering design, and welding in manufacturing must work closely together.

ENGINEERING

It is not ordinarily practical to build a complete structure from a single piece of metal. The use of two or more pieces requires that one or more joints be made. The function of welding is to produce the direct coalescence or bonding together of two or more metallic parts into one unit. The assurance that this unitization of components of any designed structure will fulfill its intended purpose is an engineering problem. Proper application of some one of the several available welding processes usually serves to provide the formation of metallic structures in accord with design specifications. Special exceptions must be recognized in advance of design.

The choice of process depends upon the particular combination of conditions which most nearly meets the requirements of any particular quantity of product at its location manufacture. Each process competes with all others on a basis of resulting quality at minimum over-all cost.

Engineering in welding applications is the successful technological co-ordination of the problems of design, material selection, process selection, and application to produce a suitable product. The substitution of welding for riveting and casting not only posed new problems in design, process selection, and application, but in material selection, and in product inspection.

Engineering contributions of the industry are demonstrated by the results achieved. Resistance welding has been reduced to a precision process. From the original crude dynamo of 1832, the regulatory welding circuits have been and are being improved constantly still. Originally arc welding was retarded by the performance and electrical characteristics of the welding machines. Now such units delivering either alternating or direct current operate effectively with both consumable and nonconsumable electrodes on a wide variety of metals.

Welding is performed by operators trained as required. Tens of thousands of such personnel, men and women, are employed in the electrical industry. It is most interesting that engineers engaged in welding have reduced the operational procedures to the point where normally available personnel can be trained to become proficient operators for a specific process-metal-product combination within a matter of days or weeks, depending upon specific circumstances. Only a few specially trained engineers are involved in any one operation. Those men are responsible for the continued maintenance of quality.

Upon reflection, it is indeed amazing that the American engineers have succeeded, without specialized formal training in the scientific aspects of welding within the framework of the engineering colleges, in altering the mode of fabrication of metallic parts without the prerequisite of highly skilled operators. The native ability of the normal workman has once again sufficed, under engineering leadership, to perform a technically complex operation as a matter of simple routine.

Present quality requirements are high. Consider that millions of individual units of a specific device may be manufactured annually. No member of the industry can tolerate a 1-per cent customer rejection rate on components, or 10,000 units per million. Yet each product may contain from one to hundreds, or even thousands, of individual welds. This is no field for chance performance. There is here an obvious challenge to the highest available engineering intellect. Neither welding research nor application engineering are fields for untrained minds. Such activities now, in addition to keeping the individual in constant challenging contact with factual technology, also keep one informed and abreast of most of the latest and forthcoming developments. Welding is a broadening, not a confining, field of activity. It is a fertile one for young engineers.

WELDING APPLICATIONS

Welding is now being so broadly employed in manufacturing that an enumeration of the specific products of the electrical industry utilizing it would essentially become a listing of the manufactured products of the industry. The problems of applications within the field of electrical manufacturing are as complex, or even more complex, than those in any other segment of industry. This results from the many metal-process-product combinations involved, ranging from precision delicate instruments and meters to rugged massive parts. The electrical industry employs every known welding process in the manufacture of its products and has developed or co-operated in the development of most of them.

Today's electric power is generated from water- or steam-driven turbines which are of welded construction. It would be between difficult and impractical to build such units without the use of welding

Generator equipment of the water-wheel impeller type for use with hydroelectric projects and those for use with steam-driven turbines both involve the daily problem of shielded metal-arc welding structural carbon steel over a range from 1/4 to 6 inches in thickness. About 95 per cent of total activity here is steel, a small percentage being silicon steel of electrical grades. Due to the massive welds involved, recent trends are towards the use of more and more automatic welding equipment, largely of the submerged-arc type. Stators, spider frames, bearing housings, bedplates, and air frame shells are fully welded. Bearing housings often involve welding cast to wrought steel.

Steam turbines, a driving source for electric generators, are of welded high-temperature alloy construction which requires the best in precision and engineering knowledge. Transformer tanks and components of all sizes used in the distribution of electric power are of welded construction. Motor components are of welded fabrication. Circular-steel-ring electric-motor-shell housings and mounting lugs are again a problem of welding structural carbon steel by both manual and automatic shielded arc welding. Railway generator frames used on diesel freight and passenger locomotives are likewise of all-welded construction, being made of wrought and cast steel.

Many millions of electric light bulbs are dependent upon resistance-welded connections. Such bulbs sell for a few cents each. The filament components are joined with welds. The effectiveness of the light bulb therefore depends, along with other things, upon the soundness and consistency of those welds. Other structural phases of commercial and industrial lighting involve welded constructions.

Among the domestic appliances of welded fabrication are refrigerators, stoves, washing and drying machines, flatirons, and water heaters. Some of these units contain hundreds of inches of welded joints, every fraction of which must be gastight. Most of these joints cannot be seen.

Other equipments of welded construction are water coolers (including the electric refrigeration unit), electric elevators and escalators, air conditioning units, the coin-in-slot cold or hot drink dispensers, the electric system of automobiles and aircraft. Common radio tubes, as well as the ignitron tube and spark plugs, are also welded.

Switchgear, commonly built to make and break electric circuits ranging from 600 to 280,000 volts, involves welding of shells, panels, framework, and oil- and pressure-tight tanks. About 95 per cent of the welding is on common structural carbon steels by manual and automatic shielded-arc processes. Continuous tight joints are automatically arc welded. Considerable resistance spot welding is used. The lesser portion of the activities is involved with aluminum alloys, brasses, and bronzes. Discontinuous and short-length welded joints are either resistance spot or manually arc welded. Completed structures range dimensionally from inches to room sized. Many components are now welded instead of cast and in other instances welding has displaced riveting.

Due to the experience gained in the welding of steam turbines, the military branches of the government requested certain segments of the electrical industry to undertake the design and construction of jet engines for the propulsion of modern aircraft. These engines are, in large part, welded assemblies involving many thousands of individual welds. This is one of the many other instances where industrial welding knowledge has aided in the forwarding of military activities.

The electrical industry may be defined, in short, as a portion of the total industry which is engaged in the manufacture of welded assemblies, although here welding is not the objective but simply a means to an end. Its usage is becoming so common that there are certain dangers arising from an underestimation of the complexity of some of the technical problems involved.

Welded products in these high-quality requirement fields must have the quality engineered into the initial product according to the highest standards of the profession. The fact that this transformation has successfully occurred within the past 30 years is a tribute to the sound judgment and integrity of American industry and of course to the individual engineers who compose the driving power and vision which cause that industry to function. The fact that annoying and expensive deficiencies still occasionally occur only indicates that applications have sometimes outsped the procurement, compilation, and dissemination of firm knowledge and that more co-ordinated effort must be expended.

RESEARCH

The changes in fabrication techniques described have occurred simultaneously with all the other advances of the industry. Always new unsolved problems have been present to retard temporarily further progress. This retardation has been sometimes haltingly and sometimes dramatically, but always continuously, converted to positive advances by the research activities of the industry, which are being continued at an accelerated rate as the need for new solutions continues to multiply.

Examples of advances in arc- and resistance-welding equipment have already been cited. Other commercial developments and the introduction of new metals and alloys for the many new products, with the added stipulation that the parts be welded, has stressed the need for close co-ordination between welding and the electrical, metallurgical, chemical, and mechanical facilities of research.

ECONOMICS

Welded applications illustrate the industrial equivalent of the biological concept of survival of the fittest. Welded manufacture is the newcomer to the industrial metals-joining field. Its widespread usage as described is not the consequence of promotional efforts on the part of a group of enthusiasts. Its acceptance is based upon the hard foundation of proved performance, improved quality, increased productivity, ease of application, and reduction in cost.

The usage of welding within the electrical industry has grown so rapidly that one cannot accurately apply the standard practice of evaluating its worth in terms of dollars saved per year. Unfortunately, such information is not available. An approximation may be made by considering that the electrical industry sells in terms of billions of dollars worth of goods and services annually. The annual savings effected by welding within the electrical industry alone can be estimated to amount to many millions of dollars. The "many millions" would be the composite sum of the worth of providing the fabrication means for those parts not otherwise feasible in practice, the savings effected by reduction in cost of procurement and operation of machine tools, savings in materials, and the total savings effected in individual increments of from pennies to dollars per assembly part on millions of those parts.

EDUCATION

The electrical industry has long been a leader in the field of stressing the need for both liberal and technical engineering education. In welding an apparent contradiction occurs. The industrial stressing of fundamentals in education is being followed by the engineering colleges and universities to such an extent that young electrical engineers may have scarcely heard of the subject of welding and they are receiving little industrial training in the subject. The practical salvation lies in the fact that much of the electrical manufacturing problem is a mechanical

one and the mechanical engineering branches of the same universities are among the leaders in promoting a more widespread understanding of the principles of modern welding as an integral part of their undergraduate curriculum.[1]

The engineering schools are gradually including courses related to welding. One school has been granting a bachelor of science degree in welding engineering for the past 10 years. The American Welding Society is sponsoring a nation-wide drive to promote more educational activity in welding. Also, the American Society for Metals is emphasizing the need for education to meet the important requirements in welding metallurgy.

SUMMARY

FUTURE ATTENTION probably will be directed towards the continuously increasing efficiency in the application of welding through better engineering based upon sound educational practices, all dictated by the requirement of quality products economically produced by mass-production techniques. Better engineering is expected to include usage of product designs intended for the best application of the most efficient existing welding process at each future time period, and employing metals which are metallurgically designed for use in welded fabrications. The product designers will, for the same reasons, evolve the most suitable combinations of welding with precutting, forming, extrusions, forgings, or castings to provide the best combined efficiency. Welding manufacturing necessarily will be reduced to a rigidly controlled technique for each metal-product combination. The days of on-the-job trial-and-error procedures are rapidly vanishing. There is a too narrow margin remaining between the profit and loss columns of most manufacturing operations to permit the continued existence of the luxury of error. Welding processes and their applications gradually will become more and more foolproof.

The establishment of an entirely new mode of fabrication of metallic parts has resulted from the chance discoveries that an arc could be struck under certain circumstances between two separated metallic conductors, and that two conductors in close contact when carrying a sufficiently high current density could heat the contact to produce bonding between the metallic interfaces. The contributions of the welding segment of the electrical industry have facilitated production, reduced the requirements of metals per part, and reduced the need for machine tools. Only incidentally it has brought into ultimate being a relatively small new industry, the manufacture of welded electric welding equipment and the processing of materials amounting to a combined total of about 110 million dollars in annual sales.[2] This amount of equipment and materials serves as the joining media for billions of dollars worth of products in all of industry.

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Automatic Focusing Device Improves Reliability of Searchlights

An automatic focusing device, which incorporates features greatly improving the simplicity and reliability of Naval aircraft searchlights, has been developed by the National Bureau of Standards (NBS). This work is part of an intensive program to improve all types of lighting equipment used on Naval aircraft.

In the NBS modification of the antisubmarine warfare searchlight, a probe control is used in such a way as to avoid any tendency to deteriorate from the heat of the arc and to eliminate any need for maintenance or adjustment. Instead of refractory materials for the probe, copper of the highest practicable thermal conductivity is used. The design aim was to conduct the heat away as rapidly as possible, rather than to withstand the high temperatures. In addition to being made of highly conductive materials, the probe is designed with considerable bulk, which permits heat flow in three dimensions. Conventional probes do not allow the heat to flow away from the tip rapidly.

The final form of the NBS probe is that of a thick disk electrically insulated from the remainder of the positive carbon drive mechanism. The positive carbon feeds through a hole in the center of the disk. The upper edge of a recess, milled out of the front edge of the disk, serves as the probe tip. Finally, the massive probe acts as an obturator, or barrier, for shielding the positive drive mechanism of the carbon from the radiant heat of the arc.

The NBS obturator-probe has a number of advantages over the thermostat-optical system it replaces. It has practically no thermal inertia and functions satisfactorily for the brief periods required of antisubmarine searchlights. Since it is permanently and rigidly attached to the positive head mechanism, there are no adjustments to make and no danger of disturbing any adjustment. It is not easily damaged or rendered inoperative by mechanical shock, vibration, dirt, corrosion, or other environmental conditions that may interfere with the operation of the thermostat-optical system.

Since the obturator-probe completely surrounds the positive carbon, its operation is very reliable, even when the arc itself for any reason becomes unstable. Arc instability may result, for example, from defects in carbons or from chipping at the positive carbon tip during striking. Such instability interferes with the accuracy of the focus control of any system and in the case of optical systems may result in complete loss of control and damage to the arc mechanism. With the obturator-probe, however, control remains effective throughout any unstable period, although there may be some reduction in accuracy. As soon as stability is restored, the control functions as accurately as before.

Current Status of Dynamic Stability Theory

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ALTHOUGH THE concept of stability of dynamical systems is important in science, there exists no theory of sufficient generality to meet the needs of engineering. As a result only the simple stability problems have been solved. However there are in use several important tools which serve to yield at least partial results in many cases.

The fundamental problem is the definition of stability. It is difficult to find one definition which will suit all purposes. "Asymptotic stability," as formulated by Liapounoff,[1] is a satisfactory tool for the investigation of the action of a regulator or a feedback amplifier, but is unsatisfactory in the treatment of conservative systems. Liapounoff's criterion of stability of so-called steady motion (temporal stability) rectifies this difficulty for cases in which the period of oscillation is independent of amplitude. In order to allow for the variation of period in periodic motion, the concept of "orbital stability" is introduced.

The three foregoing types of stability are termed "absolute stabilities." They do not provide a complete solution to all problems of stability. A servomechanism, although absolutely and asymptotically stable, may exhibit such a persistent oscillatory response as to render its usefulness no greater than if it had been unstable. On the other hand, there are cases in which zero damping, or even a slight negative damping, may be tolerated for a short time. Thus relative stability or the degree of positive or negative damping is often the proper criterion of merit.

There are three types of motion of concern here: 1. stationary points, or points of equilibrium, such as operating points of regulatory devices; 2. periodic motions, such as occur in the operation of electric oscillators; 3. any bounded or unbounded, periodic or nonperiodic, motion. The more commonly encountered types of motion are 1 and 2, and, in fact, very few tools exist which are of use in the analysis of stability of nonperiodic motion.

Two types of excitation or disturbance of systems are considered: "soft excitation" denotes any infinitesimal disturbance; "hard excitation" denotes a finite disturbance. Many systems which exhibit stability when subjected to soft excitation are unstable under hard excitation.

Liapounoff presents two methods for the investigation of stability under soft excitation, commonly called the first and second methods.[1] The former involves the investigation of the behavior of all solutions which originate in an infinitesimal region surrounding the undisturbed motion. The second method involves the investigation of the existence of a function which, in connection with the given dynamical equations, possesses a certain prescribed behavior. The difficulty in finding such restricted functions has resulted in very little use of the second method, and consequently most stability investigations are effected by means of the first method.

The tool which has been found most useful so far in the investigation of dynamic stability is the so-called method of first approximation. The procedure is contained in the following six steps.

1. *Representation of the physical system by a set of dynamical equations.* The representation is invariably in the form of differential, difference, or integral equations.
2. *Search for undisturbed motions.* If the undisturbed motions are stationary points, they are found easily by solving the static equations obtained from the dynamic equations by deleting all derivatives and differences. However if the undisturbed motions are periodically varying solutions, their determination is often most difficult. In the case of nonperiodic undisturbed motion, no general method of approach for nonlinear systems has been developed.
3. *Perturbation.* Once the undisturbed motion has been found, all disturbed motions in the neighborhood of the undisturbed motion may be found by means of perturbations.
4. *Characteristic equation.* For autonomous systems, stability is determined by the roots of the characteristic equation of the linear perturbation equations.
5. *Stability criteria.* Once the characteristic equation has been obtained, stability may be determined by application of the criteria of Nyquist or of Routh and Hurwitz.[2]
6. *Stability boundaries.* The final step is the presentation of absolute and relative stability boundaries as functions of basic system parameters.

A very powerful tool for the investigation of periodic motion is based on the so-called method of equivalent linearization. The method involves the systematic replacement of all nonlinear elements in the system by quasilinear elements which have the property of preservation of waveform but nonlinear magnification. In conjunction with the stability criterion of Nyquist,[3] equivalent linearization provides in many cases a most useful tool for the investigation of stability of nonlinear periodic motion.

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The Analysis of Sampled-Data Systems

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THERE IS AN important class of feedback control systems known as sampled-data systems in which the data at one or more points consist of trains of pulses or sequences of numbers. Such systems may be analyzed by the use of classical difference equation techniques or by employing the Laplace and Fourier transform methods. It is the purpose of this article to unify and extend the latter methods of analysis of sampled-data systems, and to formulate the input-output relationships for such systems in the frequency domain.

The Laplace transform method of analysis is based on the use of so-called generating functions[1,2] which originally were introduced by Laplace and were used extensively by him for the solution of linear difference equations. In this article, these functions are defined in terms of the Laplace transforms of impulse-modulated continuous signals and are referred to as z-transforms. More specifically, the z-transform of a continuous signal $r(t)$ $[r(t)=0$ for $t<0]$ is defined as the Laplace transform, $R^*(s)$, of the product of $r(t)$ and a train of unit impulses $\delta_T(t)$

$$R^*(s)=\mathcal{L}\{r(t)\delta_T(t)\} \tag{1}$$

where T denotes the time interval between successive impulses. It is verified readily that $R^*(s)$ may be expressed as a power series in ϵ^{-sT}

$$R^*(s)=\sum_{n=0}^{\infty} r(nT)\epsilon^{-nTs} \tag{2}$$

The z-transform $R^*(z)$ results from replacing ϵ^{sT} in $R^*(s)$ by an auxiliary variable z. In short, the z-transform of $r(t)$, $R^*(z)$, is the Laplace transform of $r(t)\delta_T(t)$, $R^*(s)$, with ϵ^{sT} replaced by z. In what follows, $R^*(s)$ and $R^*(z)$ will be used interchangeably.

When $r(t)$ is a linear combination of products of polynomials, exponential functions, and step functions, $R^*(z)$ is a rational function of z. In practice, $R^*(z)$ is obtained most readily from a table of z-transforms, which may be used in much the same manner as a table of ordinary Laplace transforms.

The derivation of input-output relationships for various types of sampled-data systems is facilitated greatly by the application of z-transformation to both sides of equations relating ordinary Laplace transforms and starred Laplace transforms (that is, z-transforms). For example, if $C(s)$ and $G(s)$ are ordinary Laplace transforms and

$$C(s)=G(s)R^*(s) \tag{3}$$

where $R^*(s)$ is a starred Laplace transform, then the application of z-transformation to both sides of equation 3 yields

$$C^*(z)=G^*(z)R^*(z) \tag{4}$$

The z-transformation technique furnishes an effective means of obtaining the expression for the z-transform, as well as the Laplace transform, of the output of a specified sampled-data system. As an illustration, for the system shown in Figure 1 the expressions for the z-transform and the Laplace transform of the output are found to be

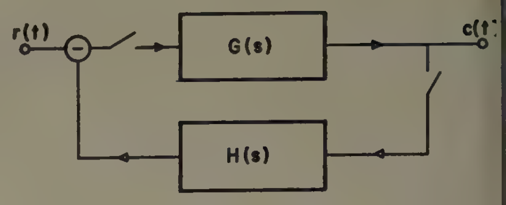

Figure 1. Typical sampled-data feedback control system

$$C^*(z)=\frac{G^*(z)R^*(z)}{1+H^*(z)G^*(z)} \tag{5}$$

$$C(s)=\frac{G(s)R^*(s)}{1+H^*(s)G^*(s)} \tag{6}$$

where $G^*(z)$ and $H^*(z)$ are the z-transforms corresponding to $G(s)$ and $H(s)$ respectively.

The stability of this system can be investigated in the conventional manner by plotting the Nyquist diagram of $H^*(z)G^*(z)$, with z traversing the unit circle, and observing whether or not the plot encloses the point $-1, 0$. The sampled response of the system to a given input may be obtained by finding the inverse z-transform of equation 5 from a table of z-transforms or, alternatively, by expanding $C^*(z)$ into a power series in z^{-1} and making use of the fact that the coefficient of z^{-n} is the ordinate of the response at the nth sampling instant.

From the z-transform $C^*(z)$ one can obtain only the values of the output at the sampling instants. In many practical cases the output is a piecewise continuous function of time and it is desired to obtain some information about the waveform between sampling instants. Such information can be obtained conveniently by treating a sampled-data system as a variable network and characterizing its behavior in terms of a system function which involves both frequency and time. This technique of analysis makes it possible to evaluate the ripple content in the output and thus to assess the effectiveness of smoothing circuits in the system.

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Typical Block Diagrams for a Transistor Digital Computer

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The superior speed capabilities of vacuum tubes have led to their use in computer designs to replace relays. Because of their small size, low power consumption, and long life expectancy, it now appears that transistors will replace tubes as computer elements. Here is a study of binary computer functions in which transistors are employed.

DIGITAL COMPUTER operations[1] can be divided into two classes: memory and logic. Memory includes the three operations write, read, and erase, where the write operation, for example, can be defined as the representation in space of a function of time. In computers, the logic operations consist of the recognition of spatial distributions of voltages and currents. All the logic operations that can be described in words can be mechanized with suitable combinations of three basic functions. The basic functions are OR, AND, and INHIBITION or negation. An n-terminal or-circuit will have an output when any one of its n input leads is energized. An n-terminal and-circuit will have an output only if all of its n leads are energized. Inhibition leads can be added to either of these two circuits with the result that the circuit cannot have an output as long as there is a signal on any of the inhibition leads.

These logic circuits have the advantage that they can be built out of passive nonlinearities. A nonlinear device has two states, a high-impedance and a low-impedance state. The more pronounced the nonlinearity, the more satisfactory the unit is as a 2-state element. Since nonlinearity can be obtained from purely passive elements, it is possible to obtain all of the logic functions of a computer without the use of vacuum tubes or other active elements. In practice, it is necessary to use some active elements because the nonlinear devices available are not ideal and have losses. It is necessary, therefore, to use amplifiers to make up for losses in the logic circuits. It is important to note that as the efficiency of the logic circuits is increased, the number of amplifiers required is decreased.

This computer design philosophy was followed in the design of the National Bureau of Standards Computer SEAC.[2] It is believed that the approach that will result in a vacuum-tubeless computer at the earliest date is to follow the SEAC example, in so far as the use of germanium diode logic circuits is concerned, but replacing the vacuum-tube amplifiers with transistor amplifiers.

Serial operation has been used in all of these designs. In serial operation all the digits of a word or number are transmitted in series along a single wire with the least significant digit first. The interval between the rise of successive digit pulses is referred to as one digit time. The interval between successive numbers or words is commonly referred to as the word time. Digit times of 1 microsecond have proved to be practicable, and words as long as 50 binary digits have been employed (equivalent to 15 decimal digits).

A number of the block diagrams presented herein have been mechanized with a transistor amplifier that regenerates pulses at a megacycle rate. This amplifier operates on a total power drain of approximately 50 milliwatts. Some details of this amplifier and the associated logic circuits have been presented by the writer in a paper, "The Transistor as a Digital Computer Component."[3]

BASIC BUILDING BLOCKS

THE PROPOSED computer elements are based on an assembly of a relatively small number of different kinds of basic units. Some of the basic components have been described in the literature.[4,5] They are described again in the following paragraphs to provide a specific basis for the estimates of numbers of parts that are a goal of this study.

An n-terminal or-circuit (see Figure 1) develops an output when any one of its input terminals is energized. Crystal diodes are put in series with each input to prevent a pulse at one input from feeding back to any of the other inputs. An n-terminal circuit, therefore, requires n crystal diodes.

An and-circuit having n input terminals develops an output only when all n of the input terminals are energized. In Figure 2 each of the inputs is returned to a negative

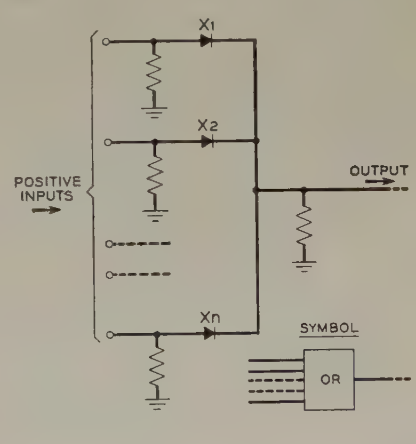

Figure 1. The or-circuit and its symbol

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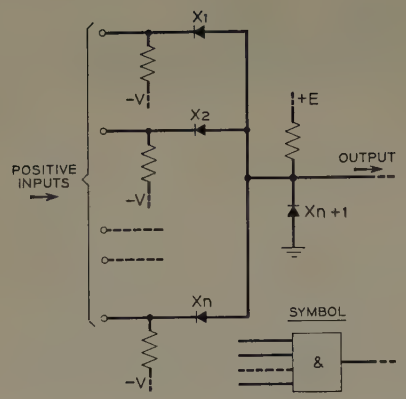

Figure 2. The and-circuit and its symbol

voltage and the output is clamped slightly below ground by X_{n+1}. Only when all of the inputs rise above ground will X_{n+1} be cut off, permitting the output to rise. Thus the output consists of the overlapping part of the inputs. An n-terminal circuit is seen to require $n+1$ crystals.

Two-terminal and-circuits are used extensively in serial computers for retiming signals. One terminal of the circuit is fed by the signal to be retimed while the other is fed by digit pulses from a master clock. There will be an output from the circuit only for the overlap of the master digit pulse and input signal. The circuit whereby the output is made a replica of the pulse from the clock is discussed in connection with the basic amplifier.

An inhibitor terminal can be added to any and-circuit or or-circuit. Such a circuit operates as though there were no inhibitor terminal when the inhibiting pulse is absent. When the inhibiting pulse is present, however, the circuit prevents any output from being developed. The inhibiting circuits used in the designs proposed herein are of the simple variety shown in Figure 3 where positive inputs synchronized in time are required. Note that the signal to be inhibited is passed through an eighth-digit delay line, while the inhibiting pulse is passed both through and around a quarter-digit delay line. This insures that the inhibitor pulse will arrive, in effect, earlier than the signal pulse and last longer. In the absence of input pulses, crystal diode X_4 will clamp the output at ground because input B is returned to a negative potential. Note that X_1 and X_2 are returned through the transformer to a positive potential. If input B goes positive (without an inhibiting pulse appearing on input A) X_4 will be cut off and the output voltage will rise until it is clamped at the positive potential to which X_1 and X_2 are returned. If there is an inhibiting pulse (positive) it is inverted by the transformer and will carry X_1 and X_2 negative, which will keep X_4 conducting, no matter what happens at B. Thus, if pulses A and B were written as a 2-digit binary number AB, the circuit translates 01 into a 1 at the output. It translates 00, 10, and 11 into zero at the output.

Active elements will be used not as flip-flops or switches but as repeating amplifiers to make up for attenuation in crystal diode circuits and delay lines. The standard use will include a retiming feature as well as amplification. Wherever a pulse is likely to suffer intolerable attenuation, deformation, or a variable delay, a circuit like that of Figure 4 is inserted in the machine.

The assembly shown has two inputs, A and B. Input A is the pulse to be retimed and amplified. Input B comes from the master clock. This component supplies reference pulses (known as digit pulses) every digit time. These pulses are available in various phases, that is, with various but accurately controlled delays of a fraction of a digit time. The pulse fed to B is selected to rise sometime between the expected rises and falls of the pulses on A.

If there is no input on A, there will be no output from the amplifier because of the and-circuit. If there is an input on A, when the digit pulse arrives the amplifier output will rise with a rise time determined by the digit pulse (assuming that the amplifier passband does not limit it). Part of the amplifier output is fed back through an or-circuit to the and-circuit. This insures that the output pulse will not fall until the reference digit pulse does, even though pulse A may have ended after B rose.

This reshaping with logic circuits and an amplifier is the way in which every pulse is maintained with the desired time synchronization. Pulse A may vary somewhat in the delay it has suffered but the output pulse will still leave the amplifier at a time determined only by the reference pulse from the master clock. Thus, the pulses in the computer are made to have fixed durations and to occur at designated times.

In the tabulations of components in the following paragraphs an active element is intended to represent as one unit a vacuum tube with transformer or a transistor. The term will include neither the and-circuit nor the or-circuit shown in Figure 4.

The basic storage cell proposed is not a static device like a flip-flop but is an electric delay line plus an amplifier. When vacuum tubes are used, this type of storage saves one active element in a 1-digit storage cell and is believed to be a more reliable use of active elements. In larger storage units more elements will be saved.

A block diagram of a cell is shown in Figure 5. The unit has three inputs: digit pulses, the signal to be stored, and an erase pulse. The digit pulses are received from the master clock every digit time and are used to retime the

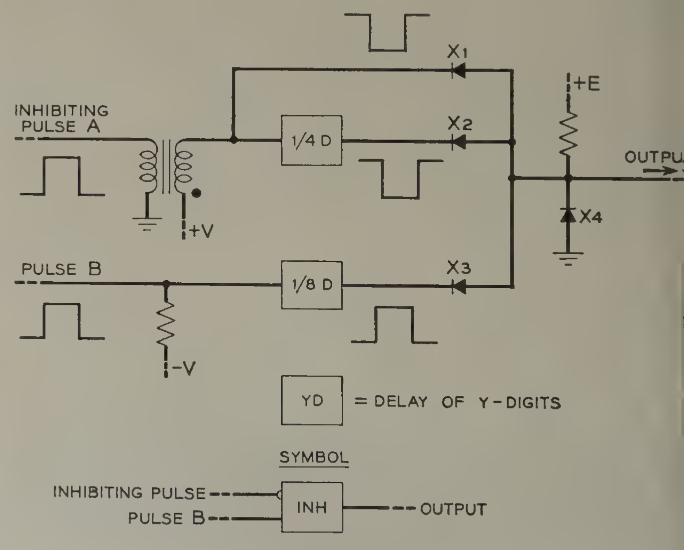

Figure 3. The inhibitor-circuit and its symbol

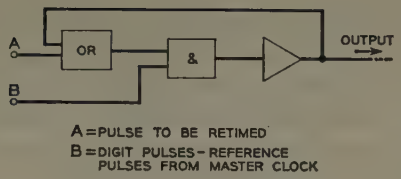

Figure 4. Amplifier with pulse retiming

output of the delay line before it is amplified and recirculated. The erase signal is received whenever new data are to be stored. It serves to erase the data in storage, blocking the delay line output from its input until the new data have been inserted.

The delay line may be long enough to store one word or just one digit of data. It is believed that up to 15-digit delay lines with lumped impedances can be built that will hold the delay constant to within a small fraction of one digit time. Depending on the length of a word, it may be necessary to break 1-word lines into sections and insert an amplifier between sections to retime and regenerate the pulses stored. To insure conservative estimates, the estimates made in following sections are on the basis of regeneration after every eight digits of delay.

The circuits which have been discussed use the components listed hereafter. Table I will be used frequently in estimating the parts required in the larger assemblies.

Table I. Basic Building Blocks

Unit	Crystal Diodes	Digits of Delay	Active Elements
N-terminal or-circuit	N	0	0
N-terminal and-circuit	N+1	0	0
Inhibitor-circuit	4	3/8	0
N-digit storage cell	10*	N	1*

* One active element will be used for $N \leq 8$; for $N \geq 8$ the number of active elements planned is the smallest integer $\geq \frac{N}{8}$. Six additional crystal diodes will be required with each active element.

SWITCHES

THE SWITCHES are planned to combine a switching and a storage function. When a switch is given instructions to go to the *k*'th position, it goes there and it remembers that it is to remain there (self-locking operation). All the elements of the switches have been discussed in preceding paragraphs. How these elements are combined to make switches is described in the following.

A single-pole double-throw switch as shown in Figure 6 consists of a storage cell and a switch unit. When a "one" is stored in the storage unit, as the result of a pulse on the switching instruction lead, the left-hand and-circuit of the switch unit will pass signal *a* while the inhibitor blocks signal *b*. When a zero is stored, the and-circuit will block signal *a* and the inhibitor-circuit in the switch unit will pass signal *b*.

Whenever the switch is to be reset, an erase signal is fed to the storage unit, which then drops its old instruction and goes to position *b* unless the new instruction sets it to *a*.

Switches with more than two positions can be assembled in a slightly different manner from the double-throw switches. Suppose, for discussion, that an 8-position switch is needed. A 3-digit code must be sent to the switch to specify the position it is to select. A convenient way to operate such a switch is to translate the 3-digit code into a 6-wire code so that each digit is represented by signals of opposite phase on a pair of wires. In this system, a one is represented by a positive pulse on the positive bus and a negative pulse on the negative bus. A zero is represented by a negative pulse on the positive bus and a positive pulse on the negative bus. A 3-terminal and-circuit is provided for each of the eight lines that may be selected. The and-circuits are operated by positive pulses, and all are connected to either one or the other of each pair of wires representing the three digits of the position code. The and-circuit of the fifth (101) wire, for example, is connected to the positive bus of the pair representing the coefficient of 2^2, to the negative bus of 2^1 and the positive bus of 2^0. The three leads of the and-circuit will be energized by positive pulses only when 101 is sent to the switch as instructions.

A single-pole 8-position switch is shown in Figure 7. The eight 3-terminal and-circuits (one for each horizontal lead), plus the 9-terminal or-circuit make an easily studied crystal matrix which feeds another and-circuit for retiming of pulses and an amplifier on the output. The and-circuits are fed by switches S_0, S_1, and S_2, which are driven by the switching instructions. These three switches are similar to

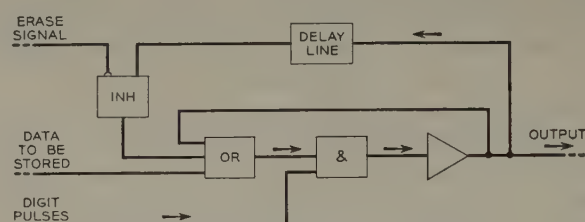

Figure 5. Block diagram of storage cell

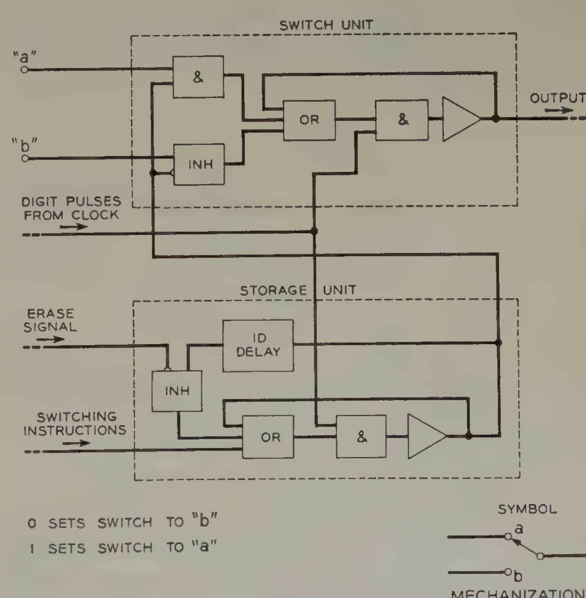

Figure 6. Block diagram of a simple switch

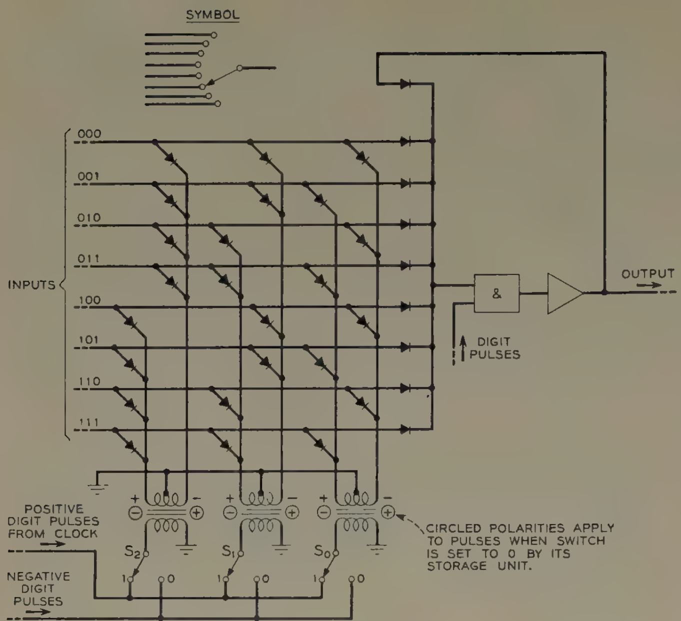

Figure 7. Diagram of an 8-position switch

the one shown in Figure 6. S_0 is operated by the coefficient of 2^0, S_1 bo the coefficient of 2^1, and S_2 by the coefficient of 2^2. As the figure is drawn, only the and-circuit on line 7 (111) is energized. A pulse will be received at the output whenever a pulse is put on line 7. Pulses can be put on any of the other lines without getting to the output, because every other line is held negative by at least one lead from S_0, S_1, or S_2. If an erase signal were sent to the three storage cells of S_0, S_1, and S_2, the number 111 would be erased, leaving 000, and the switches would be free to move to new positions and select another one of the eight inputs.

Based on this type of mechanization, an r-position switch requires n single-pole double-throw switches, where n is the smallest integer equal to or greater than $\log_2 r$. The switch requires $r(n+1)$ crystal diodes plus four diodes for retiming the output, and an output amplifier.

Table II gives estimates of the crystal diodes, digits of delay, and active elements required in switches of different degrees of complexity.

Table II

Type of Switch	Crystal Diodes	Digits of Delay	Active Elements
1P.2T	23	$1^3/_4$	2
2P.2T	36	$1^3/_4$	3
4P.2T	63	$6^1/_2$	6
1P.4T	61	$2^3/_4$	4
1P.8T	105	6	7
1P.16T	160	7	9
1P.32T	311	$8^3/_4$	11

Where 2P.2T, for example, represents a 2-pole 2-throw switch.

HANDLING OF NEGATIVE NUMBERS

THE MOST significant digit place of every number is reserved to indicate the sign of the number. Positive numbers have a zero in the last place. A negative number is obtained by taking the two's complement of the positive number. This results in every negative number having one in its last place. The system is equivalent to the ten's complement method used in decimal calculators. In a decimal calculator operating with three significant figures a fourth place might be provided for the sign. The number −187 might be represented by its ten's complement 9813. Then, for example, if −187 were required to be added to 500 the operation would be to add 9813 to 500 which gives 10313 and thus is recognized as 0313 since the machine was assumed to have only four digit places.

A negative number (two's complement) can be obtained in the binary computer by first forming the one's complement (changing all zeroes to ones and conversely by means of an inhibitor-circuit), and then adding one. Figure 8 shows several examples of binary arithmetic performed with negative numbers.

A point of interest is that even though either or both the multiplicand and multiplier are negative the correct sign will be obtained for a product provided the negative numbers are increased from their normal length W to $2W-1$ by filling in ones before multiplying. This is necessary because the product of two W-digit numbers, when the last digit specifies sign, is a number $2W-1$ digits long. Unless the multiplicand and multiplier are increased to length $2W-1$ (when negative) the $2W-1$ place may be incorrect. This lengthening is not required for positive numbers, because the digits from W to $2W-1$ would be zeroes if they were filled in and would contribute nothing to the product. A consequence is that the product XY can be obtained for $2W-1$ places with $W(W-1)$ elementary additions provided X and Y are positive while $W(2W-1)$ additions will be required if both are negative. Where fast multiplication is desired it may be advisable to convert negative numbers to positive ones, multiply, and then adjust the sign of the product.

(a) FORMATION OF NEGATIVE NUMBERS

```
+8 =                 0001000
ONES
COMPLIMENT =         1110111
ADD ONE                    1
∴ -8 =               1111000

CHECK -8+8=0
+8 =                 0001000
-8                   1111000
SUM =               1|0000000 = ZERO
TO THE MACHINE
```

(b) ADDITION

```
-8+5=-3
-8 =                 1111000
+5 =                 0000101
SUM =                1111101 = -3
CHECK +3 =           0000011
SUM =               1|0000000 = ZERO

-8+15=7
-8                   1111000
+15                  0001111
SUM =               1|0000111 = 7
```

NEGATIVE NUMBERS IN A 6 SIGNIFICANT DIGIT SYSTEM WITH ONE IN SEVENTH PLACE SIGNIFYING THAT THE NUMBER IS NEGATIVE

(c) MULTIPLICATION

```
-8x7 = -56
-8 =     1111000
 7 =     0000111

      |1111000
      |0000111
      |1111000
     1|111000
    11|11000
   000|0000
  0000|000
 00000|00
000000|0
      |1001000
       SHOWS ANSWER
        IS NEGATIVE

CHECK
-56+56=0
-56    1001000
+56     111000
     1|0000000
```

(d) ANOTHER MULTIPLICATION

```
-8x-7=+56
-8=    |1111000
-7=    |1111001
       |1111000
      0|000000
     00|00000
    111|1000
   1111|000
  11110|00
 111000|0
       |0111000
        INDICATES
        POSITIVE
        NUMBER
```

Figure 8. The way negative numbers are handled

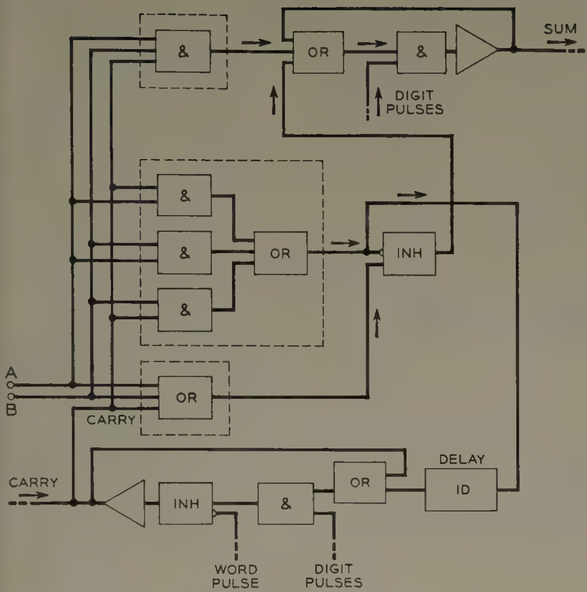

Figure 9. Block diagram of an adder

ADDER

THE ADDER can be considered as a translator with three inputs: addend, augend, and carry. It is a simple translator in that its output is a function only of the number of ones among its three inputs, as can be seen from Table III.

Table III. Binary Addition

Inputs			Outputs	
Addend	Augend	Carry	Sum	New Carry
0	0	0	0	0
0	0	1		
0	1	0	1	0
1	0	1		
0	1	1		
1	1	0	0	1
1	0	1		
1	1	1	1	1

The combination 000 is automatically taken care of in the adder shown in Figure 9. The three dashed circuits at the left of the block diagram recognize three situations among the three inputs. The situations are: at least one "one," at least two "ones," and three "ones" among the inputs. If there is only one "one," it will go through the bottom or-circuit, the following inhibitor-circuit, and then another or-circuit. After being reclocked and amplified it will provide a "one" as the sum. In this case none of the and-circuits on the A, B, and carry leads will have operated. If there are at least two "ones" on the A, B, and carry leads, at least one of the three 2-terminal and-circuits in the dashed box will operate, with two results. The output of the 3-terminal or-circuit at the bottom left of the diagram will be inhibited so that it makes no contribution to the sum. In addition, a carry signal will be developed which is delayed one digit, reclocked, and amplified to serve as the carry for the next augend and addend. If there are three "ones," the 3-terminal and-circuit at the top and left-hand side of the diagram will operate and develop a sum of one. The three 2-terminal and-circuits on the left of the diagram will have operated also and provided the carry. Thus, the adder table is mechanized with two active elements (amplifiers).

The inhibitor-circuit in series with the carry lead should be noted. This circuit is fed by a word pulse as well as the carry digits. The word pulse is received in synchronism with the first digit of every number. The word pulse will inhibit the carry pulse if one is present and will prevent a carry developed in one problem from being used in the next. This feature is required in the addition of negative numbers.

The carry lead is brought outside the adder to facilitate subtraction. Suppose x is to be subtracted from y. The number y might be fed to the addend terminal and the number x fed through an inhibitor-circuit to the augend terminal. The inhibitor would be fed also by digit pulses from the master clock, and the augend therefore would be the one's complement of x. A one would be inserted into the carry terminal in synchronism with the first digits of y and of the one's complement of x. The sum out of the adder would then be $y-x$. The adder produces a sum within a fraction of a digit time after it receives an input. Thus there is only a small delay in obtaining the sum of two numbers.

Table I can be consulted to show that the adder of Figure 9 requires 38 crystal diodes, $1^3/_8$ digits of delay, and two active elements. The operation of so many crystal diode circuits in series without amplifiers may be questioned but it is believed that it will become feasible as diodes and transistors are improved.

MULTIPLIER

THE MULTIPLIER that is discussed in the following paragraphs is designed to multiply two positive members, each having W digits, in $W(2W+1)$ digit times. Operating at a megacycle rate, the product of two 48-binary-digit numbers would be obtained in 4,656 microseconds. It is believed most efficient to convert all negative members to positive ones before multiplying and to adjust the sign of the product according to the rules of algebraic multiplication. The components to be added to the multiplier to make the sign correction have not been included in this study. The multiplicand (x) is multiplied by the first

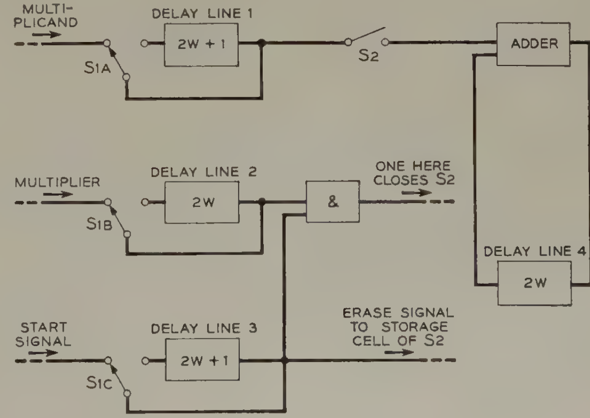

Figure 10. Block diagram of a multiplier

TIME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MULTIPLICAND	0	1	1					0	1	1					0	1	1
MULTIPLIER	1	0	1				1	0	1				1	0	1		
START	1							1							1		
SWITCH	←			CLOSED			→	←			OPEN			→	←	CLOSED	
ADDEND	0	1	1					0	0	0					0	1	1
AUGEND	0	0	0				0	1	1				0	1	1	0	
SUM	0	1	1				0	1	1	0			0	1	1	1	1

Figure 11. The operation of a multiplier

(least significant) digit of the multiplier (y) in the first ($2W+1$) period and by the W'th digit of y during the W'th ($2W+1$) period. The W partial products are added together, with each partial product moved over one place with respect to the preceding one as it is accumulated.

The multiplication table in binary arithmetic is very simple. If it is desired to multiply the binary number x by a single binary digit m, x is connected to the input of a switch that is held open if $m=0$, and closed if $m=1$. The output of the switch will be mx. Thus, in multiplying x by the successive digits of the number y, it is only required to pass x through a switch that is opened and closed at the appropriate times according to whether the successive digits of y are zeroes or ones.

The block diagram of a multiplier is shown in Figure 10. The multiplicand (x) is stored in delay line 1, and the multiplier (y) is stored in delay line 2. After the first word period, $S1-A$, $S1-B$, and $S1-C$ are thrown to position b and the multiplier, multiplicand, and start pulse recirculate in their delay lines until the multiplication is finished. $DL1$ (delay line 1) storing the multiplicand has one more digit of delay than line $DL2$ in which the multiplier is stored. Therefore, after the first circulation of x through $DL1$, the least significant digit of x leaves $DL1$ just as the second least significant digit of y leaves $DL2$. After the W-1'th circulation of x, its least significant digit leaves $DL1$ just as the most significant digit of y leaves $DL2$.

The output of $DL2$ is fed continuously to an and-circuit. Every $2W+1$ digits, an examining pulse is fed to the and-circuit from $DL3$, and if the digit of y coming out of $DL2$ is a one at that time, the and-circuit develops a one in its output. If, when the examining pulse comes along, the coefficient of y leaving $DL2$ is a zero, the and-circuit will have no output. Because $DL2$ has a delay of $2w$ digits, the and-circuit in effect filters out the successive digits of y, choosing a new digit every $2w+1$ digits times. The examining pulse is also sent to $S2$, where it is the erase signal of the storage cell associated with $S2$. The output of the and-circuit goes to $S2$ as switching instruction and is stored there. Thus, $S2$ stores either a one or a zero, according to whether the digit of y examined is a one or a zero. The switch is arranged so that when a one is stored, $S2$ is closed, and when a zero is stored, it is open. The examining pulse is developed from the start pulse which is received by the multiplier coincident with the first digits of x and y and recirculated in delay line 3.

A new partial product is obtained at the output of $S2$ every $2w+1$ digit times by the process described in the foregoing. To accumulate them, an adder is provid[ed] which accepts as one input the output of $S2$, and as th[e] other input its own sum output delay by $2w$ digits. Th[e] one digit place difference in the arrival of the two inpu[ts] of the adder automatically provides the "shift" featu[re] necessary in adding the partial products. Figure 11 show[s] a digit by digit account of the operation of a 3-digit multi[-]plier when multiplying 110 by 101.

A multiplier based on Figure 10 can be mechanized f[or] 48 digit words with 390 crystals, approximately 390 digi[ts] of delay, and 55 active elements.

CONCLUSIONS

A SELECTION of digital computer components has bee[n] given in block diagram form with estimates of th[e] number of parts they require. The designs have th[e] common feature of using active elements as amplifie[rs] only. The principal conclusion to be drawn is that a[n] all-semiconductor computer can be built with diodes an[d] transistors. This article has been written as a contributio[n] towards the development of such a computer.

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Electron Tube Eliminates Glare

A small electron tube that is extremely sensitive to ligh[t] is helping to remove glare, the bane of night drivers, from the nation's highways. The tube, a multiplier phototub[e] pioneered by the Tube Department of RCA Victor, an essential component in the "Autronic Eye," an auto[-]matic headlight beam control developed by the Genera[l] Motors Corporation.

Mounted behind the windshield of an automobile, th[e] autronic eye sees what the driver sees and electronicall[y] selects the safest headlight beam to suit approaching roa[d] conditions. The eye relieves the driver from the respons[i-]bility of constantly operating the conventional foot switc[h] to dim or brighten his headlights.

The multiplier phototube, nerve center of the contro[l] device, is extremely sensitive to light. When it picks u[p] light from approaching traffic, it triggers a control circu[it] which dims the headlights of the car on which it is installe[d] and keeps them dim until the other vehicle or vehicles hav[e] passed. Similarly, it dims the headlights when the ca[r] enters well-lighted streets, and brightens them when th[e] car enters darkened streets or highways.

Application of Completely Self-Protected Banking Transformers in Secondary Banks

H. R. MOORE S. L. CORBIN

Secondary banking, employing completely self-protected banking transformers, is held to offer distinct advantages over the conventional radial connection under certain conditions. It reduces voltage flicker, provides better voltage regulation, less overload problems, and greater reliability. The use of low-voltage circuit breakers instead of fuses provides co-ordinated protection and eliminates the possibility of cascading.

THE Electrical Engineering Department of Mississippi State College has initiated a program of service to the industries in the surrounding area which promises to be very helpful in promoting the industrial growth of that section. Various research projects and experiments are carried on in the new Patterson Engineering Laboratories to work out problems encountered by these power companies and industries. Also, new practices and methods are developed which may prove beneficial to the utility companies in this area. One such project was the application of completely self-protected banking (cspb) transformers in secondary banks.

This project was set up to investigate a new way of improving service to customers by the use of secondary banking employing cspb transformers. Mississippi State College has nine of these transformers which were used in obtaining data for this article. Figure 1 shows the experimental bank, consisting of three cspb transformers, as it was set up in the new Power System Analysis Laboratory.

SURVEY OF SUBJECT

THE RADIAL SECONDARY SYSTEM is the most commonly used type of distribution system in residential sections today, but in certain cases it is not the most efficient. The radial system is easily overloaded, and outages due to overloads are common on some radial systems. Lamp flicker and poor voltage regulation are among the other disadvantages of the radial system, which can make this connection of distribution transformers undesirable.

Secondary banking offers a practical solution to many of the problems encountered in radial systems employed in residential and relatively densely populated rural areas. However, secondary banking has not proved popular with power companies in the past due to difficulties encountered with circuit protection. Previously, the circuit protection used for secondary-banked transformers has been obtained by fuses. The co-ordination of fuses is at best a difficult job. In addition, cascading of the transformers may occur in secondary banks using fused protection.

The cspb transformer is ideal for secondary banking because it provides a means of sectionalizing the secondary mains of the bank. This transformer has all the protective and operating features of the completely self-protected type, the major difference being that two internal secondary circuit breakers are used.

The test circuit used for the experimental work reported in this article is shown in Figure 2. In order that test results might conform as nearly as possible to actual conditions, reactors were designed and built for use in the lines between the transformers. These reactors were designed to have an inductive reactance of 0.1 ohm at 60 cycles and a resistance of approximately 0.1 ohm. These values correspond to the impedance of approximately 1,000 feet of number 6 copper wire at 1-foot spacings. The transformers shown in Figure 2 are rated at 5 kva, 60 cycles, and either 480 or 240 primary volts with a secondary voltage of 240/120 volts, 3 wire.

DISCUSSION OF RESULTS

SECONDARY BANKING may be used to prevent overloading of one section of a radial secondary system. As can be seen from Figure 2, all the transformers of the bank are connected in parallel, and thus all share the system load. If one section of the bank becomes overloaded, the remaining transformers in the bank feed current into the overloaded section. Table I shows the results of tests made to determine the contribution of the remainder of a bank to an overloaded section. These tests were run using a circuit similar to that shown in Figure 2. A load was connected midway between transformers *A* and *B*, with no load on the remaining section of the bank. Similar tests were made with the load connected at a point 1/4 of the line length from transformer *A*. These results show

Table I. Contribution of Third Transformer to Load Between Remaining Two Transformers in Secondary Bank

	Per Cent of Total Load Current Supplied by Transformer C	
Load Current	Load at Mid-Point between Transformers A and B	Load at 1/4 Line Length From Transformer A
14	12.1	11.4
21	12.6	11.5
25	12.8	11.6
31	12.8	12.8
37	12.8	12.8
41	12.8	12.8

Revised text of a paper which won the second prize in the National Student Competition for papers presented during the period August 1, 1950, to July 31, 1951.

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that all transformers of a bank share the load and tend to relieve the overloaded transformers.

The variation of voltage regulation with per-cent load for the secondary-banked connection and the radial connection is shown in Figure 3. All sections of the bank were equally loaded when using the banked connection. The same per-cent load with respect to kilovolt-ampere capacity was placed on both the banked and radial connections. In each case, the same impedance was connected between the transformer terminals and the load. Figure 3 indicates that the voltage regulation is considerably poorer for the radial connection as compared to the banked secondary.

Voltage flicker has become a greater problem with the increasing use of motor-driven appliances. It is serious on some heavily overloaded radial systems. When using the banked secondary, two transformers feed into each section of the secondary between two adjacent transformers. Thus, the voltage drop from each transformer is only half the value of that which would obtain from one transformer serving the same load for the same line length.

To determine the flicker voltages on radial and banked-secondary systems, a number of tests were conducted under different load conditions for both types of circuits. A pulsating load was connected to the line and the results were obtained by a recording voltmeter placed at the load. The voltmeter chart from these tests is shown in Figure 4.

To investigate the flicker voltages under different loads on the secondary bank, the following conditions were studied:

1. One section fully loaded with no load on the other sections.
2. Two sections fully loaded with no load on the third section.
3. All sections fully loaded.

The flicker voltages representing these conditions are shown on Figure 4 by points *A*, *B*, and *C* respectively. The results indicate that the flicker was approximately constant for all these conditions.

Tests were next conducted using a radial connection. The same pulsating load was used on this test as that used for the bank. The results of these tests are shown on Figure 4 at point *D*. This chart indicates that the flicker

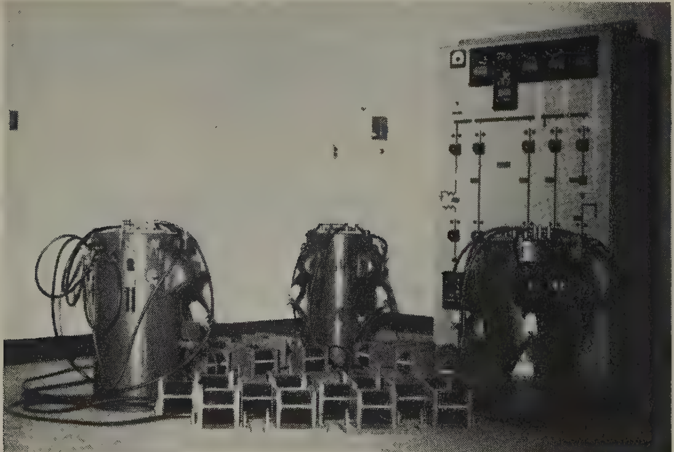

Figure 1. Experimental bank of cspb transformers

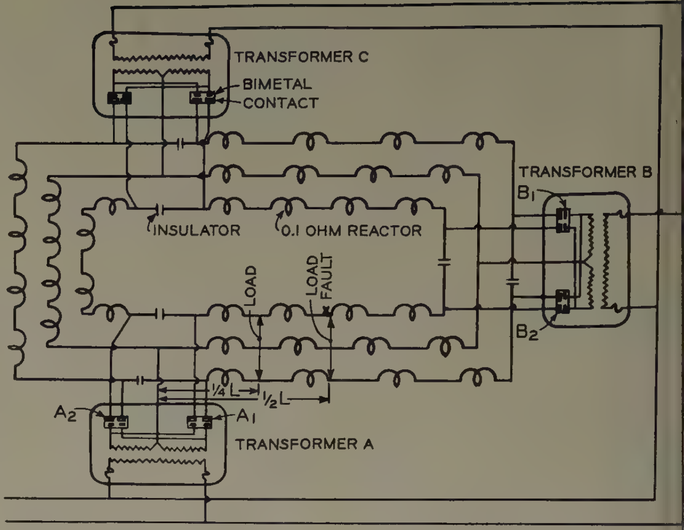

Figure 2. Experimental circuit of secondary bank

on the radial connection is approximately twice the flicker resulting when using the banked connection.

To illustrate the advantages of loop banks over line banks, tests were conducted on a line bank. Point *E* on Figure 4 represents the flicker at the mid-point between two transformers, and point *F* represents the flicker at the end points of the line bank. These results show that a consumer at the end of a line bank is no better off than a consumer served by a radial system. These results also indicate that about a 50-per-cent reduction in flicker voltage was accomplished by means of secondary banking with the loop bank.

It should be noted that poor voltage regulation and voltage flicker can be improved on the radial secondary system by installing larger transformers and larger secondaries. Larger transformers also can be installed to correct overload conditions on the radial system. However, the cost to install larger transformers and secondaries on an existing system would be considerable in most instances.

The most important feature of the cspb transformer is its ability to sectionalize different sections of a secondary bank by the use of calibrated low-voltage circuit breakers. Tests were conducted to determine the operation of the circuit breakers under actual fault conditions. A permanent line-to-line fault was placed at point *X* on the bank as shown in Figure 2. Immediately after the fault was applied, circuit breakers A_1 and B_2 opened. This operation dropped the faulted section from the line, and the remaining sections continued with no interruption. Similar faults were placed line-to-neutral, and the circuit breakers operated as before.

This operation was accomplished as follows: The fault received current from transformer *A* through bimetal A_1, and from transformer *C* through bimetals C_2 and C_1 of transformer *A* in series. Therefore, the fault current through bimetal *1* was always greater than that through bimetal *2* so that bimetal *1* opened contact *1* first. From the other direction, the fault received current from transformer *B* through bimetal *2*, and from transformer *C* through bimetals *1* and *2* of transformer *B* in series. Therefore, the fault current through bimetal *2* was always greater

than that through bimetal *1*, so that bimetal *2* opened contact *2* first. Thus, the faulted section was isolated, and only loads in this section of the line were disconnected. All transformers stayed on the line and supplied power to the remaining loaded sections. The signal lights on the sides of transformers *A* and *B* adjacent to the fault came on to show that these circuit breakers had tripped.

When an overload greater than 300 per cent of the rated load was placed on the system, the circuit breaker action was similar to that of the faulted condition, but ample advance warning of the overload was given by the signal lights which came on long before the circuit breakers tripped. This operation has great practical use, as the signal lights show the location of an overloaded section of the bank. Thus, the power company will have advance notice of the overloaded condition. However, if the warning is not heeded, the transformer windings are protected by the low-voltage circuit breakers and will not be damaged.

Therefore, it appears that the most objectionable feature of secondary banking has been eliminated by providing low-voltage circuit breakers to isolate the faulted sections of the bank. Thus, cascading cannot occur.

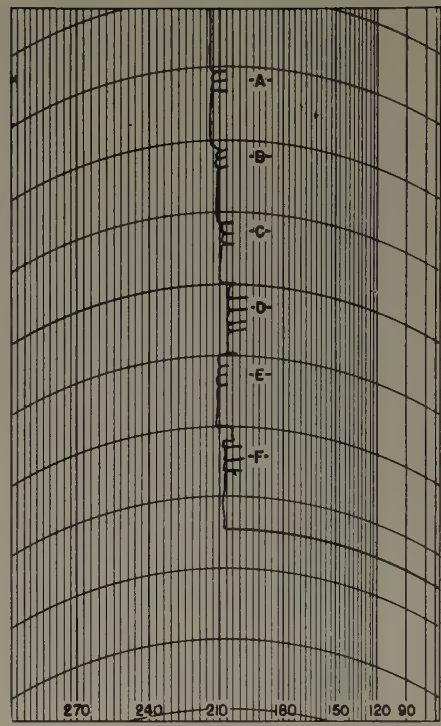

Figure 4. Voltmeter chart of voltage flicker

A—Loop bank, one section loaded
B—Loop bank, two sections loaded
C—Loop bank, all sections loaded
D—Radial connection
E—Line bank, load between transformers
F—Line bank, load at ends

COST OF SECONDARY BANKING

It cannot be said that any distribution system is practical until the cost of that system has been considered. Although the authors of this article could not make a practical cost analysis of secondary banking, the following factors were considered.

The secondary bank requires additional copper to close the loop; however, the additional copper needed should be small in most residential areas. The greater load diversity gained by the use of secondary banking permits a reduction in transformer installed kilovolt-ampere capacity. Installed kilovolt-ampere capacity may be reduced further due to the fact that, in secondary banking, excess kilovolt-amperes need not be installed to correct voltage regulation and voltage flicker problems.

The cspb transformer has a slightly higher cost than the conventional transformer due to the two low-voltage circuit breakers. However, the cost to protect the secondary circuit of a secondary bank with fuses generally would be equal to or greater than the additional cost of the cspb transformers. Also the operating cost of the power company should be reduced when using cspb transformers because more reliable secondary protection is obtained with the co-ordinated low-voltage circuit breakers. The loss of transformers due to burn-outs caused by overloads is eliminated because the windings of the cspb transformer are completely protected by the low-voltage circuit breakers and the high-voltage protective link.

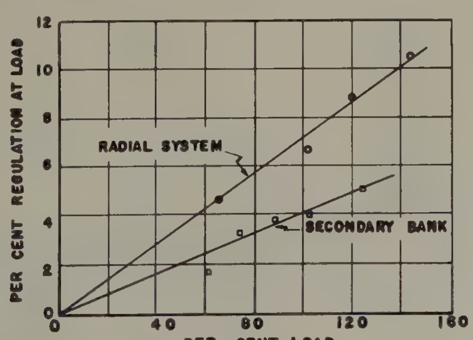

Figure 3. Comparison between voltage regulation of radial system and secondary bank with all the sections equally loaded

It is recognized that secondary banking might not be practical in some areas. A comparative cost analysis using catalogue prices of equipment, and available data to establish installation, operating, and maintenance costs would be necessary for each application. However, it is believed that the cost to serve heavily loaded residential areas with secondary banking should be less, in general, than the cost to serve the same area with a radial system.

CONCLUSIONS

To summarize the conclusions of this article, it can be said that secondary banking offers many distinct advantages over the conventional radial connection. These advantages are: reduction of voltage flicker, better voltage regulation, fewer overload troubles, and greater circuit reliability. Although secondary banking offers these advantages, the system will not function properly without proper circuit protection.

The problems of proper co-ordination of secondary protective devices are solved by completely eliminating all secondary fuses. Instead of secondary fuses, cspb transformers have low-voltage circuit breakers which provide co-ordinated protection and are not influenced by lighting surges.

It is felt that cspb transformers largely eliminate the objectionable features of secondary banking, making it possible to take advantage of secondary banking as an economical means of caring for load growth, improving average voltage conditions, and reducing voltage flicker.

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Cooling Rotating Aircraft Electric Equipment

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THE STEADILY INCREASING upper limits in flight speed and altitude for modern aircraft make the study of cooling systems for rotating electric equipment imperative. Experience with conventional fan- and blast-cooling systems indicates poor cooling performance under many of the high-altitude high-speed conditions presently encountered. Several factors, such as decreasing air density at altitude which results in decreasing available pressure drop, air-weight flow, and heat transfer coefficients, contribute to equipment overheating. Further, the air pickup drag incurred in blast cooling can result in a loss of aircraft carrying capacity many times greater than the difference in weight between a blast-cooled system and a heavier system utilizing some other cooling method. For example, it is possible for some blast-cooling installations to incur drag penalties of the order of magnitude shown in Figure 1.

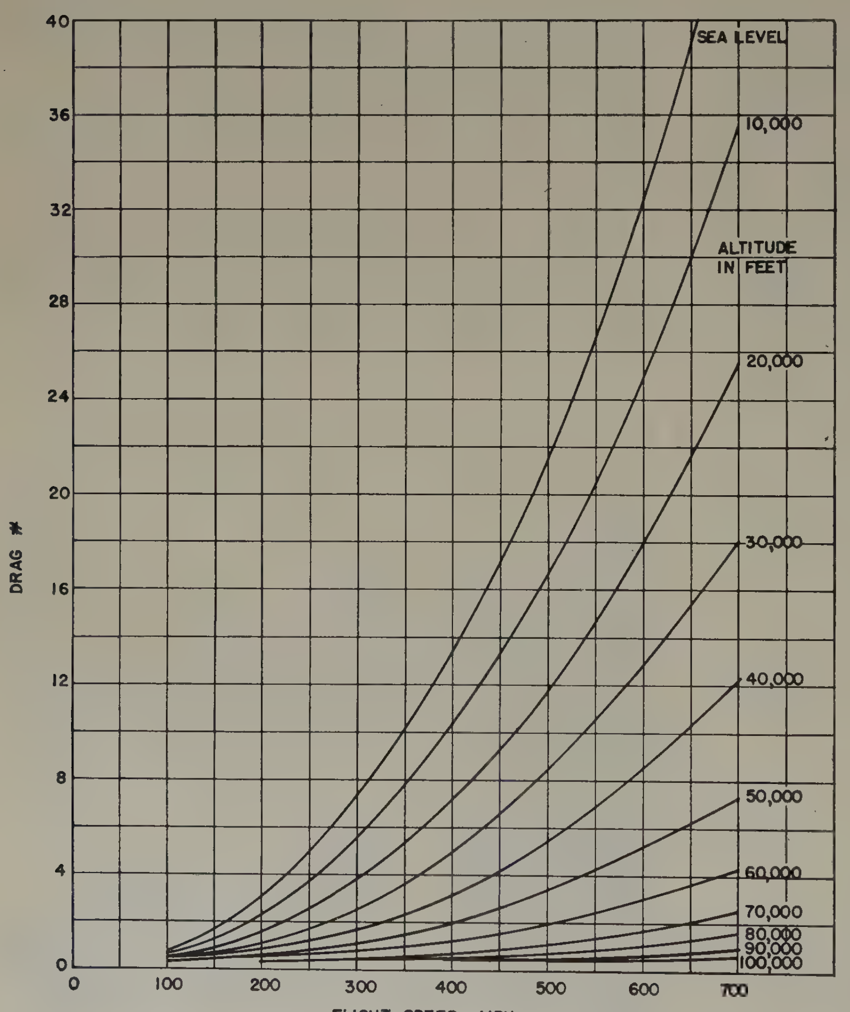

Figure 1. Effect of altitude and flight speed on pickup drag of a 400-ampere 30-volt military specification generator

Among the many criteria which may be used in establishing the merit of a particular cooling configuration are system weight; system size; ease of installation and maintenance; range of applicability; fuel consumption and carrying capacity penalties on the aircraft; and reliability and simplicity.

The systems considered are grouped in four general classifications: open ventilated, totally enclosed, compressor bleed, and closed recirculating. In each group, one or more systems show sufficient promise in overcoming certain environmental difficulties to be worthy of further consideration and study.

Evaluation of the various possible cooling configurations leads to the following general conclusions.

1. Present blast-cooled, fan-cooled, and totally enclosed machines give satisfactory service in the great majority of present aircraft. However, at high altitudes and/or high speeds, other systems will be needed and will extract a lower over-all weight, drag, and volume penalty from the airplane than the present systems.

2. Of all the systems considered, expendable evaporative cooling appears to offer the greatest promise of essentially environment-free operation. By insulating the machine and evaporant supply, it can be made completely independent of its surroundings. For short flights, it also could replace economically blast cooling.

3. The cooling of totally enclosed machines could benefit appreciably from techniques of pressurization and conduction through the mounting pad where possible.

4. Air-turbine-driven generators using the turbine exhaust for cooling show advantages that should be investigated, especially with selective compressor pressure take-off at moderate altitudes. This could be particularly true when tied in with the cabin refrigeration system.

5. Utilization of cabin exhaust air for cooling appears to be limited now to small, highly efficient machines.

6. Of the closed recirculating systems, the fuel-cooled heat exchanger types show most promise. These systems seem very practical for many current installations.

Digest of paper 52-136, "Study of Aircraft Cooling Systems for Rotating Electric Equipment," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Weathering and Crack Resistance of Black Polyethylene for Wire and Cable

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In studying the crack resistance and weathering characteristics of polyethylene, considerable data have been collected which are presented here. The controlling factors and their practical significance are described.

FOR 3 YEARS following its initial manufacture in the United States, polyethylene was used solely as a high-frequency dielectric, for radar cables in particular. After the end of World War II, this excellent dielectric material found use as insulation for frequency-modulation and television twin lead, microphone cables, signal system wire, and many other similar applications. The outstanding dielectric properties of polyethylene as described in the literature[1–4] make such applications possible. Polyethylene also has excellent low-temperature flexibility.

The degradation in physical properties of the polyethylene which occurs upon outdoor exposure was reported by Maibauer and Myers.[5] Because polyethylene is not permanently resistant to ultraviolet rays present in sunlight, it was not used as an outdoor protective coating in the early years. This deficiency was later overcome by adding small concentrations of a medium channel carbon black. The improvement is sufficient to warrant the use of this pigmented polymer as an outdoor protective coating according to Wallder, Clark, DeCoste, and Howard.[6] The characteristics of a black pigmented polyethylene which influence weathering life are carbon black concentration and degree of dispersion.

In practice, an additional problem has been encountered with polyethylene protective cable coverings. Following installation, cable sheaths were found to crack and split open. This phenomenon was found to be due to stresses applied during installation in the presence of materials such as cable pulling greases, or pressure testing soap solutions. DeCoste, Malm, and Wallder report that this phenomenon can be brought about by exposing stressed polyethylene to a large variety of chemical environments.[7]

LIGHT ABSORPTION MEASUREMENTS

IN STUDYING THE EFFECT of carbon black concentration and dispersion, a quantitative method of evaluation was necessary. Such a test based on light absorption was developed.

The intensity of light that has passed through an absorbing medium is given by Bouger's law

$$I = I_0\epsilon - \alpha x \qquad (1)$$

Full text of paper 52-205, "Weathering and Crack Resistance of Black Polyethylene for Wire and Cable" recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Not scheduled for publication in AIEE *Transactions*.

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where I_0 is the intensity of the incident light, corrected for reflection losses, α is the absorption coefficient, and x is the thickness of the absorbing medium.

I, I_0, and x can be measured and α computed. It is recognized that α is a maximum when the ultimate particles are distributed uniformly throughout the medium, hence, α is a measure of the dispersion.

The absorption coefficient is also a function of the concentration of the absorber, but since this work was done primarily at one concentration it was not included in the computation.

Light transmission measurements were made with an integrating sphere photometer, shown in Figure 1. This unit conforms to the requirements of the American Society for Testing Materials (ASTM) Method *D1003-49T*. Measurements were made as follows: Film specimens of 0.5 to 1.5 mil thickness were prepared by pressing. Specimens 3/16 inch larger in diameter than the incident light beam were die-cut from these films. The thickness was computed from the weight, density, and area of the specimen. It is necessary that the specimens be uniform in thickness since the computed absorption coefficient is a maximum for a specimen of uniform thickness. Specimens that appeared uniform when held before a strong light proved to be satisfactory. To hold the specimen in the photometer and center it in the light beam a 3- by 3-inch opaque plastic sheet was used. A hole 1/8 inch less in diameter than the specimens was cut in the center of this sheet. The specimen was attached by double-

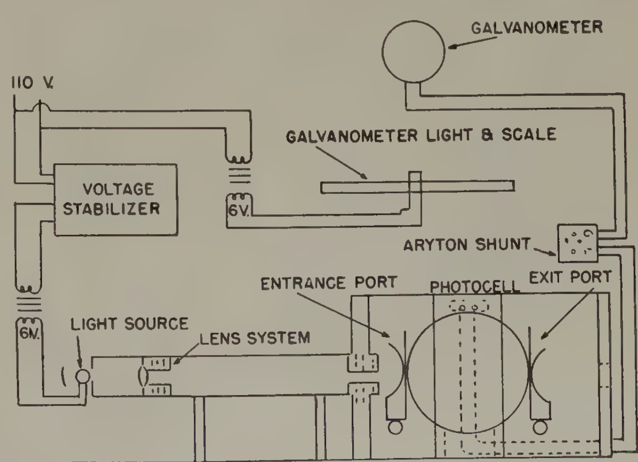

Figure 1. Diagram of integrating sphere photometer

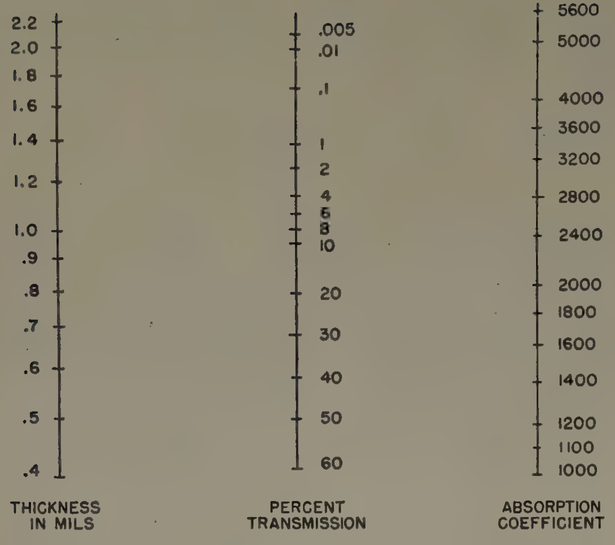

Figure 2. Nomograph for calculating light absorption coefficients

surfaced pressure-sensitive tape around the edge of the hole. This method was used to insure that light transmission and thickness measurement would be made on the same area of the pressed film.

A magnesium carbonate block was placed over the exit port of the sphere. The galvanometer deflections without and with the specimen over the entrance port were determined and the per cent transmission computed from the ratio of the deflections. It was found necessary to correct the deflection obtained with the specimen in place for slight phosphorescence of the sphere.

The transmission of an unpigmented film of polyethylene was found to be 91.7 per cent. Substitution of this value and the transmission, T, of the specimen for I_0 and I in equation 1 and the light absorption coefficient is found by solving the equation for α.

$$\alpha = \frac{2.3 \log \dfrac{91.7}{T}}{x} \tag{2}$$

A nomograph that can be utilized for solving this equation is given in Figure 2.

The permissible concentration of carbon black is limited by its degrading influence on the original low-temperature flexibility or brittleness and other physical properties of polyethylene. Smith and Dienes[8] have shown that polyethylene does not possess a sharp brittle point but is characterized by a distribution of failures over a temperature range. They have described a statistical brittleness test which conforms to ASTM *D 746-44T*. The brittleness data herein reported are the percentage of failures or nonfailures at the stated temperatures. In all cases 15 specimens were tested at each temperature. Table I shows the effect of carbon black on the brittle temperature. It is evident that increasing the concentration elevates the brittle temperature. When concentrations of 25.0 per cent carbon black are reached, the polyethylene compound is brittle at room temperature. The effects of high carbon-black concentration on the physical properties of polyethylene are described by Bostwick and Carey.[9] Thus, it is desirable to maintain maximum initial low-temperature flexibility consistent with weathering protection by limiting the carbon black concentration to 2 per cent.

Table I. Brittle Temperature of Polyethylene DYNH Effect of Carbon Black Concentration

Kosmos BB Carbon Black, Per Cent	Brittle Temperature, Degrees Centigrade 80 Per Cent Nonfailures
0.0	−74
1.0	−66
2.0	−60
5.0	−42

Figure 3 illustrates the dependence of weathering protection on carbon black concentration. In this work the weathering performance was studied by weathering tests conducted in an *X1A* WeatherOmeter modified in accordance with the Bell Telephone Laboratories' recommendations.[6] In this case the polyethylene compounds contain 1.0 and 2.0 per cent Kosmos *BB* carbon black in *DYNH* resin* and the dispersions are equivalent as rated by visual examination at 100×magnification.[6] The 2.0 per cent carbon black compound resisted the degrading influence of the radiation for about twice as long as the 1.0 per cent carbon black compound before 50 per cent brittleness failures at −40 degrees centigrade were ex-

* Molecular weight, 21,000; Williams plasticity, 55 mils.

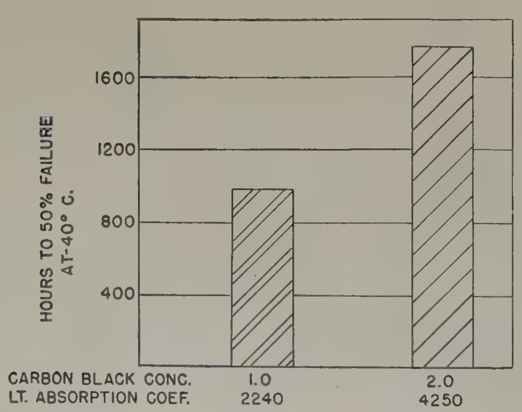

Figure 3. Effect of carbon black concentration on accelerated weathering

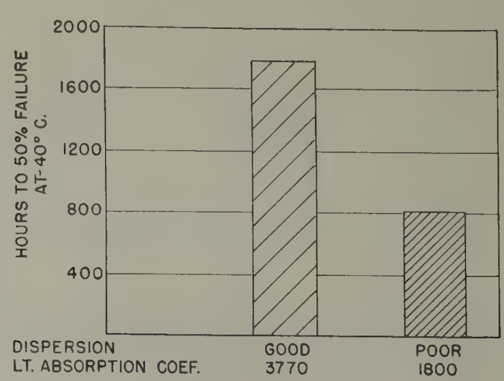

Figure 4. Effect of dispersion on accelerated weathering

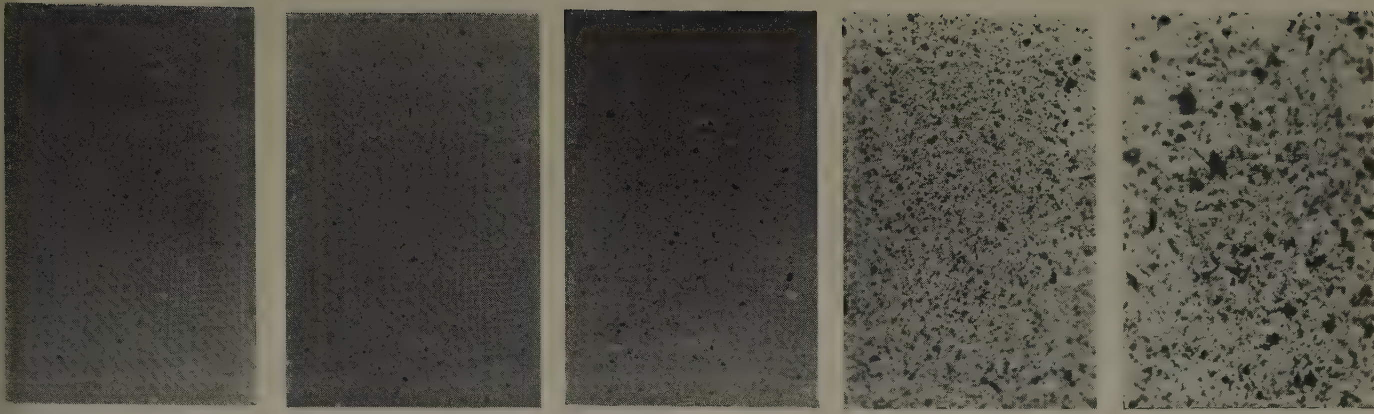

Figure 5. Appearance of carbon black dispersions: 100×microscope. Left to right they are: very good; good; fair; poor; and very poor

perienced. The light absorption coefficient, a measure of light screening, for the 2.0 per cent black compound is also about double that of the 1.0 per cent black compound.

In order to realize the best possible weathering protection from the carbon black contained in a polyethylene compound, it is necessary that the black be well dispersed. Compounds with poor dispersions will fail early in the exposure period. Figure 4 shows the difference in weathering performance of a good and poor dispersion of 2.0 per cent carbon black in polyethylene *DYNH*.

These types of dispersions are readily distinguished by examination of a sample at 100×magnification, since the poor dispersion exhibits a very poor background while the good dispersion exhibits a dense, dark background. See Figure 5. Once a given background density is reached, however, it is difficult to determine the quality of a dispersion by this procedure because at this level the quality of a dispersion can be judged only by the condition of the visible agglomerates. Figure 6 illustrates this point.

These dispersions, although rated as being different by the microscope examination procedure, are not significantly different in weathering performance. This must mean that although the dispersions appear different under a microscope because of differences in visible agglomeration, the effectiveness of the dispersed carbon black as a light screen is the same in both samples. It is a well-known fact that the fine particle carbon blacks readily form agglomerates when agitated and that once these are formed they are difficult to break down. It is reasonable to expect that a particular distribution of agglomerated black particles exists in any carbon black compound. If few agglomerates are visible in a dispersion at 100× magnification, it cannot be assumed that none exist below the visible range.

Since the effectiveness of a carbon black dispersion is believed to be dependent on light screening, light absorption measurements should correlate with weathering performance. A correlation was established by compounding two special cable-grade polyethylene resins, *DYNJ** and *DYNK***, with 2.0 per cent carbon black so that five degrees of dispersion as rated by the microscope method were obtained. Light absorption was measured and samples of each compound were weathered in the modified *X1A* WeatherOmeter. The data obtained with the *DYNJ* compound are shown in Figure 7 and with the *DYNK* compound in Figure 8.

According to the microscope rating, the dispersions were different from one another, and therefore the weathering life of each material should be different. Actually the very good, good, and fair dispersions weathered equally well. This performance was predicted by the light absorption levels since the coefficients for these three dispersions were approximately equal. The poor and very poor dispersions did not weather well, a condition which also was predicted by their light absorption coefficients. These particular compounds weather longer before excessive embrittlement occurs than the *DYNH* compounds described earlier because of their superior initial low-temperature brittleness. Figure 9 is a summation of Figures 7 and 8. Outstanding weathering life for black polyethylene compounds with light absorption coefficients above 3,500 is indicated.

These data substantiate the earlier statement that the microscope technique recognizes only gross differences in dispersion. The light absorption coefficient on the other hand correlates very well with accelerated weathering and more accurately predicts the weathering life of a polyethylene compound of specified type of carbon black.

ENVIRONMENTAL STRESS CRACKING

The phenomena of environmental stress cracking has been described by DeCoste, Malm, and Wallder.[7]

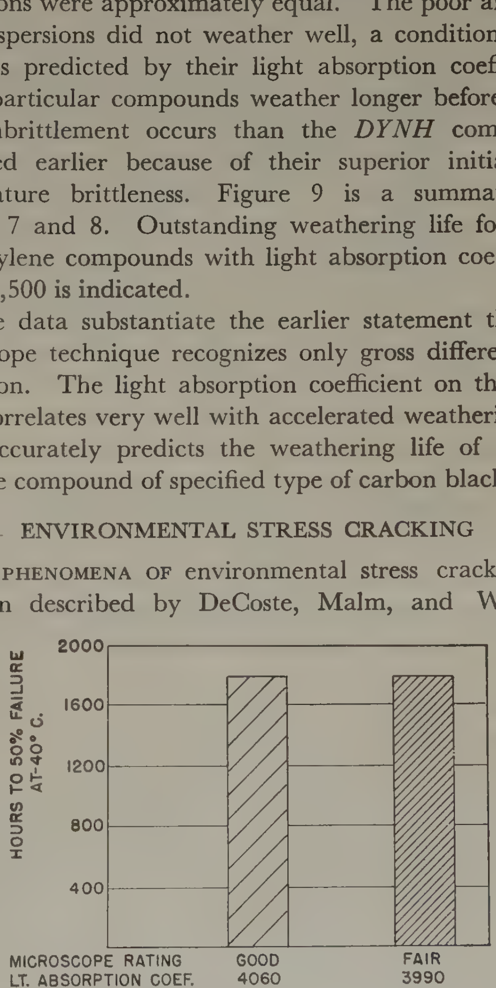

Figure 6. Microscope rating and light absorption versus accelerated weathering

* Molecular weight, 22,500; Williams plasticity, 65 mils.

** Molecular weight, 24,500; Williams plasticity, 75 mils.

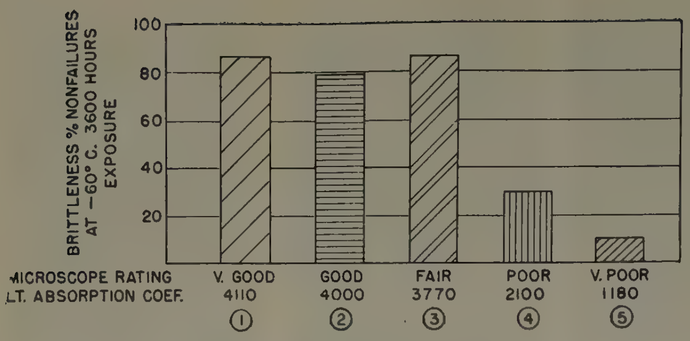

Figure 7. DYNJ compounds

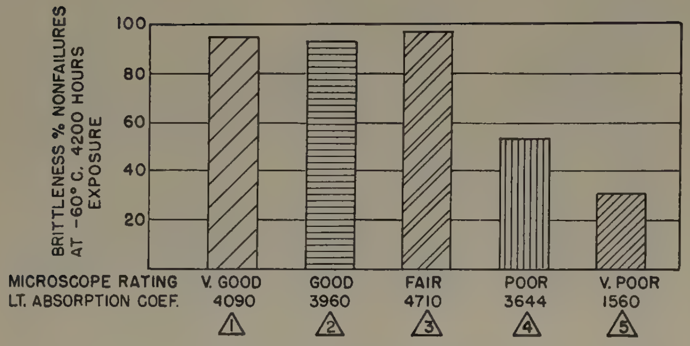

Figure 8. DYNK compounds

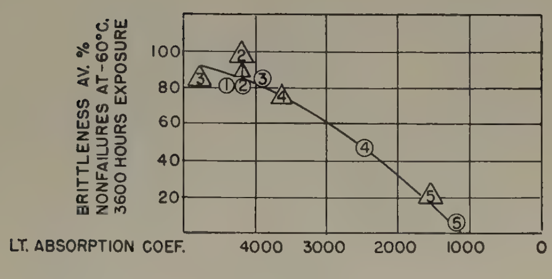

Figure 9. DYNJ and DYNK compounds

They have been mainly concerned with cracking failures of heavy walled cables. It might appear that the usefulness of polyethylene would be rather limited in certain applications because of this cracking liability. However, this is not entirely true when the polymer is employed carefully. Almost every material similarly used has deficiencies and it is well to consider each in a practical way.

Carey[10] has shown that the elastic limit of polyethylene at room temperature is reached at about 4.0 per cent strain, and yielding is quite pronounced at 7 to 10 per cent strain. Extruded polyethylene sections of relatively small thickness are not nearly so susceptible to stress cracking as thick specimens. Smaller radius bends can be tolerated in thin walled wires and cables in the presence of cracking agents with a reasonable margin of safety. Table II shows the effect of specimen thickness on the susceptibility of polyethylene *DYNH* to stress cracking with 1/2 inch radius bend and scored circumferentially with a razor blade to insure stress concentration.

Table II. Cracking of DYNH

Sample	Thickness, Mils	Cracking Time Ethyl Alcohol at 25 Degrees Centigrade, Seconds
A	120	15
B	100	84
C	80	850
D	60	28,800 (8 hours)

The type of stress referred to in environmental cracking has sometimes been confused with the residual internal strain obtained in extruded sections caused by cold drawing after extrusion or by strains developed by nonuniform temperatures throughout the compound during extrusion or by nonuniform die pressures. This type of strain can be released by subjecting the section to a temperature above the melting point, that is, at 130 degrees centigrade for 4 hours. The measure of percentage strain thereby relieved is sometimes referred to as shrinkage. This type of strain of magnitudes normally encountered in extrusion, does not appear to be a factor affecting cracking resistance. Figure 10 shows the relative cracking resistance of polyethylene *DYNH* with a fairly wide range of internal strain. No correlation of percentage strain or shrinkage with cracking resistant is evident.

A significant effect on the cracking resistance of polyethylene can be brought about by varying the extrusion conditions. Higher compound temperatures and cold quenching of extruded sections yield a more crack-resistant polyethylene. Figure 11 shows the relative crack resistance of polyethylene *DYNH* as affected by the variables of compound temperature during extrusion and cooling rate. Although there is some evidence[7] to show that the improved cracking resistance, of cold quenched polyethylene is gradually lost and approaches that of the annealed state by shelf aging, there is at least an initial advantage, and the higher molecular weight polymers have a less pronounced tendency toward such change. It has been established that the stiffness of polyethylene increases by cooling slowly after extrusion. Figure 12 shows the effect on the stiffness of extruded polyethylene

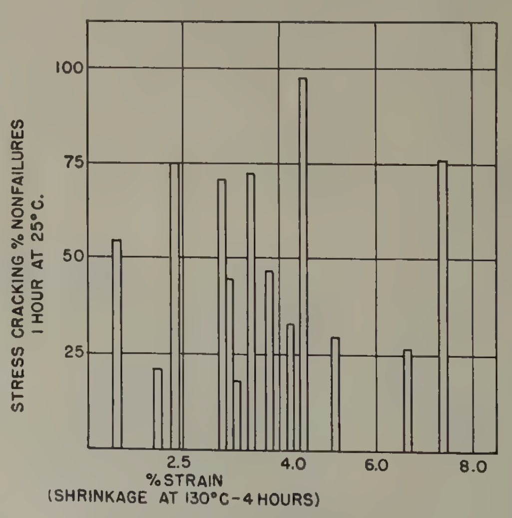

Figure 10. Crack resistance of DYNH tested in ethyl alcohol

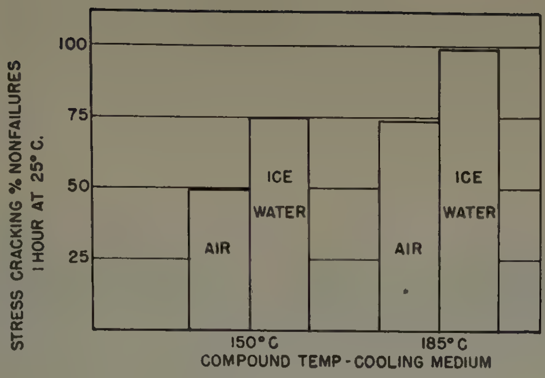

Figure 11. Cracking resistance of DYNH in ethyl alcohol

DYNH by the rate of cooling, giving the cooling medium temperature. Some polyethylene, especially below the plasticity range of *D-40*, with an average molecular weight of 18,000, cracks in a polar solvent, such as ethyl alcohol, in seconds, whereas polyethylene of higher plasticity, with an average molecular weight of 24,500, such as *D-75*, exhibits no cracking in the same environment. Figure 13 shows the relative cracking resistance of four grades of polyethylene tested in Igepal CA in accordance with methods described by DeCoste, Malm, and Wallder.[7]

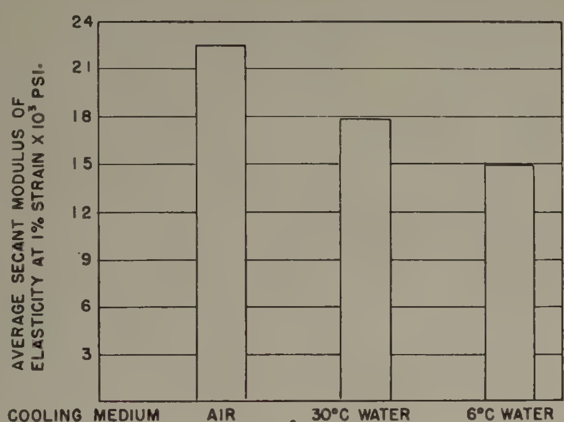

Figure 12. Stiffness of DYNH

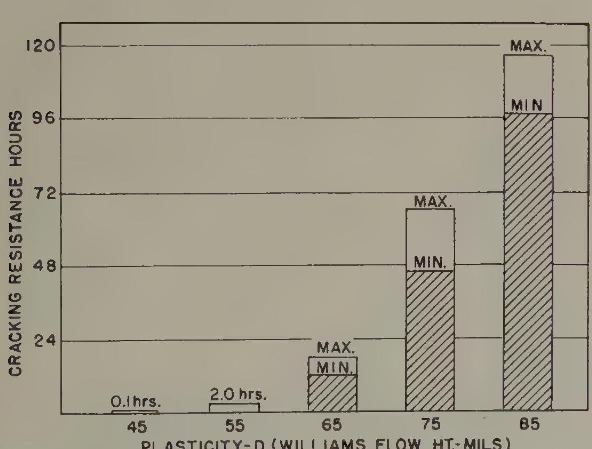

Figure 13. Cracking resistance of polyethylene in Igepal CA at 50 degrees centigrade

The greatest vulnerability of polyethylene to environmental stress cracking is during the early stages of the applied stress. This is because polyethylene specimens after being stressed for periods of time gradually yield and the stress is relaxed to a low level. After long periods of time the specimens will become almost permanently set in the deformed shape, so that the deformed polyethylene acts like unstressed polyethylene with regard to cracking resistance. Samples of *D-75* polyethylene which had not cracked in Igepal CA after 72 hours were found to resist cracking for 90 days thereafter, at which point the tests were discontinued.

The addition of small concentrations, up to 5 per cent of pigments, fillers, or antioxidants, have no adverse effect on the cracking resistance of polyethylene. In fact, there is some evidence which indicates that many additives such as rubbers and polyisobutylene improve the cracking resistance of polyethylene.

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Applied Mathematics Survey

The National Science Foundation has contracted with the National Academy of Sciences for a broad survey of research and training in applied mathematics in the United States. The survey is expected to be completed in 1 year.

The survey group will seek to determine the nature and extent of research in this field being carried out by government, universities, and industry. It will also report on the training and teaching in applied mathematics and will indicate the areas which are not receiving adequate support. As part of the study, a conference on training and research needs in applied mathematics will be held during the spring of 1953 to consider the findings of the survey and to examine the future of research and teaching in this field. Data and recommendations of the survey and the conference will be made available to all agencies.

A New Control for Trolley Coaches

N. H. WILLBY
MEMBER AIEE

A NEW TROLLEY COACH CONTROL has been developed to operate with a motor which is series-excited in acceleration and shunt-excited in dynamic braking. Reliability and low maintenance have been stressed in keeping with the trolley coach reputation as the lowest cost vehicle.

In acceleration, the motor operates as a straight series motor. It is started by commutating a resistor in the well-known manner and uses a current-limit relay for automatic acceleration. This device will allow each successive resistor notch to be taken at the same current value after current has built up to the indicated value. Field shunting is employed to obtain greater speed after all resistance is cut out.

In dynamic braking, the motor armature is connected across a fixed resistor which dissipates the braking energy. The shunt field is excited from the line, and its circuit passes through a portion of the fixed resistor which is across the motor armature. By this circuit, the shunt field excitation is decreased as the armature current increases. This gives a self-regulating dynamic brake which requires only a set-up circuit to give full brake over a wide speed range. At maximum speed armature current is high and field current is low. As the vehicle speed decreases the armature current declines and the shunt field current increases to maintain substantially constant braking effort. At about 10 miles per hour, the braking effort starts to fade. At about 3 miles per hour, the shunt field is opened automatically and the stop is finished and the vehicle held by air brakes. Different rates of braking are obtained by inserting resistance in the shunt field circuit. This 1-step automatic dynamic brake is well suited to trolley coach requirements. This brake gives a maximum of reliability with a minimum of control functioning. In addition, the braking response is immediate and uniform.

The control apparatus is assembled into a control panel and a resistor panel as shown in Figures 1 and 2. The control panel includes a large contactor to act as a line switch and to open in case of overload, an overload relay, a master and brake controller, four small contactors to handle the shunt field circuit, a cam controller to commutate the acceleration resistor, a power-brake changeover to set up power and brake circuits, and a relay to open the shunt field circuit at the end of the braking cycle. The master controller contains three shafts. One controls acceleration, another braking, and the third reverses the main motor field to reverse direction of motion. The current-limit relay also is included to control accelerating current. Different rates of acceleration are obtained by stretching the current-limit relay spring when the power pedal is depressed. The power-brake changeover is incorporated as part of the cam controller and includes two cam switches actuated by a separate air cylinder and magnet valve. One cam switch closes the power circuit, and the other closes the dynamic braking loop. Since both switches are operated by a single cam, the need for electrical interlocking between power and brake circuits is eliminated. A suppressor is connected permanently across the shunt field to reduce peak voltages.

Figure 1. Main control panel

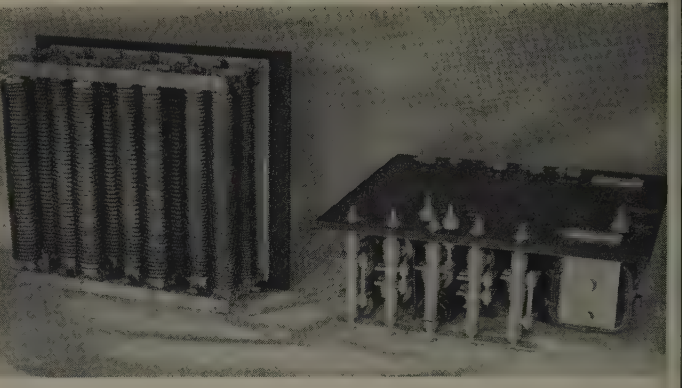

Figure 2. Resistor panel

A feature of the acceleration connection is a small coil on the current-limit relay connected across the shunt field of the motor which is otherwise unused in acceleration. Through transformer action, this coil reflects each increase of accelerating current in the series field and momentarily overexcites the relay. This modifies the acceleration to reduce peaks, producing a smoother vehicle without any added moving parts or added electric contacts.

The reliability and reduction in maintenance which this new control was expected to produce has been demonstrated by a small number of equipments which have been in service for about 1 year. Larger numbers of equipments are being delivered to two other cities and are going into service rapidly. Their record to date fully lives up to expectations.

Digest of paper 52-38, "A New Control for Trolley Coaches," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Ground Fault Relay Protection of Transmission Lines

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MOST TRANSMISSION SYSTEMS are grounded, usually solidly, and at several points. Consequently, except on a few cases, ample ground or residual current and voltage are available for ground relaying. Negative-sequence quantities also are used. None of these quantities are present during normal balanced 3-phase operation so that separate relays can be used, set sensitively, and below 3-phase load.

Four different basic methods of ground relaying are in general use: inverse time overcurrent, instantaneous overcurrent, reactance, and pilot differential. These can be subdivided further into directional or nondirectional types. The order of these is roughly that of increased speed of operation and increased cost. The problem of application is to determine the type that will give adequate protection for the degree of service required of the circuit.

In multiple-grounded loop systems, directional-type relays are necessary. These operate only when the fault power flows into the line section. To determine this direction, a reference known as the polarizing quantity is necessary. Current polarization is obtained by using the current in the grounded neutral or in the delta of a star-delta power transformer bank. For three winding transformers with a delta, both grounded neutrals must have current transformers paralleled with their ratios inversely proportional to the bank voltages. Autotransformers for current polarization require special study. Zero-sequence voltage as measured across the broken delta of a star-grounded-potential transformer or device provides polarization. Where these quantities are not available, negative-sequence current and voltage are used to operate the directional relay. This is particularly valuable where there are no grounded power transformers and only open-delta potential transformers, or where parallel line induction is a problem.

The large majority of ground relay systems use inverse time overcurrent protection. This may provide the primary protection for the lines or be used as a secondary system for back-up protection. For high-current close-in faults the relays should operate fast. However, for lower current faults near or at the remote end of the line, they must operate with time delay if they are to co-ordinate with bus differential relays or other line relays radiating from the remote bus. In this system time delay is the only means the relay has of determining the location of the remote fault. Each relay must select or co-ordinate with all other relays which may operate on any given fault. Such selective settings and operation are necessary to isolate the trouble area with a minimum number of circuit-breaker operations. Since the time setting of each relay depends upon the time setting of other relays, a definite final setting for any relay cannot be determined except by trial and error. This is complicated further by changing system conditions which will give varying operating quantities to the relays. Usually this can be resolved into two limits designated as maximum and minimum operating conditions. These provide two sets of fault data for which the relay must be set to co-ordinate. In cases where more operating conditions with various lines in or out of service must be considered, the relay operation must be reviewed for each such case.

Instantaneous-type relays, unless controlled by carrier, pilot wire, and so forth, usually are employed only to supplement inverse time relays. Many transmission lines of moderate or long length provide inherent directional overcurrent discrimination as the result of the variation in fault-current magnitude for the near and remote faults. Where this occurs, the addition of instantaneous overcurrent elements to the inverse time relays will give relay operating times in the order of 1 cycle for a good portion of the line with a minimum of additional cost.

Relays responsive to the reactance or distance from the relay location to the fault provide instantaneous protection for the majority of the transmission line relatively independent of the variation in generating capacity or to line switching. Unfortunately there are inherent difficulties in the measurement of impedance or reactance during ground faults.

Pilot differential relaying refers to the various systems where the conditions at one terminal are compared with similar conditions at the other terminals to determine whether the fault is within the transmission line section or external. The most important advantage is that all line terminals can be relayed simultaneously and instantaneously for all faults both phase and particularly ground. This isolates the fault quickly and before it can spread appreciably. Also it permits immediate restoration of the line by automatic reclosing on the basis that most line faults are flashovers that can be cleared by de-energizing the line for a few cycles.

For the comparison, some forms of communicating channel between the remotely separated line terminals is necessary. This can be pilot wires (usually two or one pair), carrier frequency superimposed on the transmission line, or microwave beamed between the terminals.

There are two different relay schemes in common use. One is the power-directional comparison scheme generally used with power line carrier although it has been used over pilot wires, audio tones on carrier and microwave. The other is the phase-comparison scheme, originally developed for pilot wires, and later modified for use over carrier or microwave channels.

Digest of paper 52-182, "Ground Fault Relay Protection," recommended by the AIEE Committee on Relays and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Approved Working Definitions for Color Television

PANEL 19, NATIONAL TELEVISION SYSTEM COMMITTEE

THESE TENTATIVE DEFINITIONS of color television terms, prepared by Panel 19 under the chairmanship of R. M. Bowie, were approved for publication by the National Television System Committee (NTSC), W. R. G. Baker, Chairman, on August 6, 1952. Emphasis is placed on their tentative nature, as undoubtedly changes will be made as the art and usage of these terms progress. However, they are published at this time to indicate that work has been and continues to be done to bring color television closer to realization once full-scale effort again can be devoted to research in this field.

Black-and-White: Deprecated (see *Monochrome*).

Brightness: The attribute of visual perception in accordance with which an area appears to emit more or less light.
Note: Luminance is recommended for the photometric quantity which has been called *brightness*. Luminance is a purely photometric quantity. Use of this name permits *brightness* to be used entirely with reference to the sensory response. The photometric quantity has been confused often with the sensation merely because of the use of one name for two distinct ideas. *Brightness* will continue to be used properly in nonquantitative statements, especially with reference to sensations and perceptions of light. Thus, it is correct to refer to a *brightness match*, even in the field of a photometer, because the sensations are matched, and only by inference are the photometric quantities (luminances) equal. Likewise, a photometer in which such matches are made will continue to be called an *equality-of-brightness* photometer.
A photoelectric instrument calibrated in foot-lamberts should not be called a *brightness meter*. If correctly calibrated, it is a *luminance meter*. A troublesome paradox is eliminated by the proposed distinction of nomenclature. The luminance of a surface may be doubled, yet it will be permissible to say that the brightness is not doubled, since the sensation which is called *brightness* is generally judged not to be doubled.

Brightness Channel: Deprecated (see *Monochrome Channel*, *Luminance Channel*).

Brightness Signal: See *Monochrome Signal*.

Burst Pedestal (Color Burst Pedestal): The rectangular pulselike component which may be part of the color burst. The amplitude of the color burst pedestal is measured from the *AC* axis of the sine-wave portion to the horizontal pedestal.

Bypass Mixed Highs: The mixed-highs signal that is shunted around the color-subcarrier modulator or demodulator.

Bypass Monochrome Signal: A monochrome signal that is shunted around the color-subcarrier modulator or demodulator.

Camera Spectral Characteristic: The sensitivity of each of the camera color-separation channels with respect to wavelength.
Note 1: It is necessary to state the camera terminals at which the characteristics apply.
Note 2: Due to nonlinearity, the spectral characteristics of some kinds of cameras depend upon the magnitude of radiance used in their measurement.
Note 3: Nonlinearizing and matrixing operations may be performed within the camera.

Camera Taking Characteristics: Deprecated (see *Camera Spectral Characteristic*).

Carrier Color Signal: The sidebands of the modulated color subcarrier (plus the color subcarrier, if not suppressed) which are added to the monochrome signal to convey color information.

Chrominance: The colorimetric difference between any color and a reference color of equal luminance, the reference color having a specified chromaticity.
Note: In NTSC transmission the specified chromaticity is the zero subcarrier chromaticity.

Chrominance Channel: In a color television system any path which is intended to carry the carrier color signal.

The membership of Panel 19, National Television System Committee is as follows: **Dr. R. M. Bowie,** *Chairman;* **M. W. Baldwin, Jr.,** *Vice-Chairman;* **Edward Sieminski,** *Secretary;* **A. V. Bedford; Scott Helt; C. J. Hirsch; P. W. Howells; R. E. Waggener; R. P. Burr** and **R. C. Moore,** alternates.

Color Burst: That portion of the composite color signal comprising the few sine-wave cycles of color subcarrier frequency (and the color burst pedestal, if present) which is added to the horizontal pedestal for synchronizing the color-carrier reference.

Color Carrier: See *Color Subcarrier.*

Color-Carrier Reference: A continuous signal having the same frequency as the color subcarrier and having fixed phase with respect to the color burst. This signal is used for the purposes of modulation at the transmitter and demodulation at the receiver.

Color Co-ordinate Transformation: Computation of the tristimulus values of colors in terms of one set of primaries from the tristimulus values of the same colors in another set of primaries.
Note: This computation may be performed electrically in a color television system.

Color Difference Signal: An electric signal which, when added to the monochrome signal, produces a signal representative of one of the tristimulus values (with respect to a stated set of primaries) of the transmitted color.

Color Edging: Spurious color at the boundaries of differently colored areas in the picture.
Note: Color edging includes color fringing, misregistration, and so forth.

Color Phase (of a given subcarrier component): The phase, with respect to the color-carrier reference, of that component of the carrier color signal which transmits a particular color signal.

Color Phase Alternation (CPA): The periodic changing of the color phase of one or more components of the color subcarrier between two sets of assigned values.
Note 1: In the NTSC system the color phase is changed after every field.
Note 2: It is recommended that the term *Color Phase Alternation* be used in place of the terms *Oscillating Color Sequence* and *Flip-Flop*, which have been used with this same meaning.

Color Picture Signal: The electric signal which represents color picture information, consisting of a monochrome component plus a subcarrier modulated with color information, excluding synchronizing signals.

Color Subcarrier: The carrier whose modulation sidebands are added to the monochrome signal to convey color information.

Color Sync Signal: See *Color Burst.*

Color Transmission: In television, the transmission of a signal wave for controlling both the luminance values and the chromaticity values in a picture.

Compatibility: The nature of a color television system which permits substantially normal monochrome reception of the transmission by typical unaltered monochrome receivers designed for standard monochrome.

Composite Color Signal: The color picture including blanking and all synchronizing signals.

Constant Luminance Transmission: A method of color transmission in which the carrier color signal controls the chromaticity of the produced image without affecting the luminance, the luminance being controlled by the monochrome signal.

Delay Distortion: That form of distortion which occurs when the envelope delay of a circuit or system is not constant over the frequency range required for transmission.

Envelope Delay: The first derivative of the phase shift with reference to the frequency.
Note: If the phase is measured in radians and the frequency in radians per second, the envelope delay will be in seconds.

Field: One of the two (or more) equal parts into which a frame is divided in interlaced scanning.

Flip-Flop: Deprecated (see *Color Phase Alternation*).

Frequency Overlap: In a color television system that part of the frequency band which is common to the monochrome channel and the color channel.
Note: Frequency overlap is a form of band-sharing.

Gamma: In a color or monochrome channel, or part thereof, the coefficient expressing the selected evaluation of the slope of the used part of the log versus log plot relating input (abscissa) and output (ordinate) signal magnitudes as measured from the point corresponding to some reference black level.
Note 1: As the log versus log plot is usually not entirely straight in the used region, it is necessary to formalize that evaluation of the slope, for example, by the use of the value at a particular point, maximum, mean, or other value. The method of evaluation must be stated.
Note 2: At some points the signal may be in terms of light intensity or light transmission.

Gamma Correction: The modification of a transfer characteristic for the purpose of changing the value of gamma.

Luminance: Luminous flux emitted, reflected, or transmitted per unit solid angle per unit projected area of the source.
Note 1: Usual units are the lumen per steradian per square meter, the candle per square foot, the lambert, the millilambert, and the foot-lambert.
Note 2: This quantity is also called photometric brightness.

Luminance Channel: In a color television system any path which is intended to carry the luminance signal.
Note: The luminance channel may also carry other signals, for example, the carrier color signal, which may or may not be used.

Luminance Signal: A signal wave which is intended to have exclusive control of luminance picture.

Luminosity: Ratio of photometric quantity to corresponding radiometric quantity in standard units (lumens per watt).

Luminous Flux: The time rate of flow of light. When radiant flux is evaluated with respect to its capacity to evoke the brightness attribute of visual sensation, it is called luminous flux, and this capacity is expressed in lumens.

Matrix:
A. (*Noun*) In color television an array of coefficients symbolic of an operation to be performed, which operation results in a color co-ordinate transformation. (This definition is consistent with current mathematical usage.)
B. (*Verb*) In color television, to perform a color co-ordinate transformation by computation or by electrical, optical, or other means.

Matrixer (Matrix Unit, Matrix Circuit, and so forth): A device which performs a color co-ordinate transformation by electrical, optical, or other means.

Mixed Highs: Those high-frequency components of the picture signal which are intended to be reproduced achromatically in a color picture.

Modulated Color Subcarrier: See *Carrier Color Signal.*

Moire: In television the spurious pattern in the reproduced picture resulting from interference beats between two sets of periodic structures in the image.
Note: Moires may be produced, for example, by interference between regular patterns in the original subject and the target grid in an image orthicon, between patterns in the subject and the line pattern and the pattern of phosphor dots of a 3-color kinescope, and between any of these patterns and the pattern produced by the carrier color signal.

Monochrome Bandwidth (of the signal): The video bandwidth of the monochrome signal.

Monochrome Bandwidth (of the monochrome channel): The video bandwidth of the monochrome channel.

Monochrome Channel: In a color television transmission, any path which is intended to carry the monochrome signal.
Note: The monochrome channel may also carry other signals, for example, the carrier color signal which may or may not be used.

Monochrome Signal:
A. In monochrome television transmission, a signal wave for controlling the luminance values in the picture but not the chromaticity values.
B. In color television transmission, that part of the signal wave which has the major control of the luminance of the color picture and which controls the luminance of the picture produced by a conventional monochrome receiver.

Monochrome Transmission: In television the transmission of a signal wave for controlling the luminance values in the picture, but not the chromaticity values.

Oscillating Color Sequence: Deprecated (see *Color Phase Alternation*).

Pickup Spectral Characteristic: The set of spectral responses of the device, including the optical parts, which converts radiation to electric signals, prior to any nonlinearizing and matrixing operations.

Receiver Primaries: The colors of constant chromaticity and variable luminance produced by the receiver, which, when mixed in proper proportions, are used to produce other colors.
Note: Usually three primaries are used: red, green, and blue.

Stationary CPA Axis: A fixed reference phase with respect to which a carrier color signal of constant chrominance makes equal and opposite angles for successive fields, this reference phase being the same for all chrominances.

Taking Characteristic: See *Camera Spectral Characteristic.*

Zero Subcarrier Chromaticity: The chromaticity which is intended to be displayed when the subcarrier amplitude is zero.

Design of Low-Frequency Constant Time Delay Lines

C. M. WALLIS
FELLOW AIEE

A TIME DELAY LINE for low-frequency signals normally consists of a cascade connection of inductance-capacitance networks employing lumped constants. There are a number of types of low pass sections that are particularly useful where constant delay of signals ranging in frequency from near zero to some arbitrary upper limit, is required. Several of these, such as the M-derived and the bridged-T, have received considerable attention and have been discussed.[1] However, one whose delay characteristic and simplicity of construction compares very favorably with others is the Pierce unsymmetrical section.

The Pierce unsymmetrical section is a T-type structure with two coils, connected series aiding, in the series arm of the T and a capacitor connected between their junction and ground as shown in Figure 1 for the standard section. The coils are wound on a common magnetic core so as to have a coupling coefficient as close to unity as possible. The coil self-inductances, designated as L_1 and L_2, are made unequal. When the sections are connected in an iterative manner[2] to form a line, and proper termination is made, constancy of delay time within ± 1 per cent over 60 per cent of the passband may be secured.

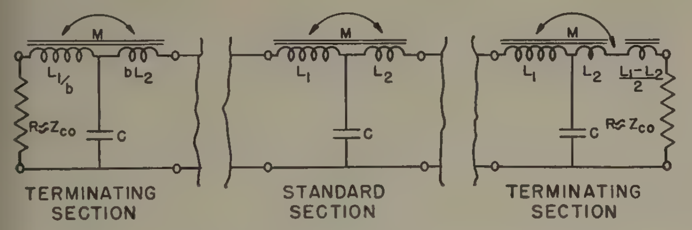

Figure 1. A method of terminating the Pierce delay line

If the ratio of L_1 to L_2, herein designated as r, is made large and the coupling coefficient k approximates unity, the design equations for the section can be expressed as follows. For the cut-off frequency

$$f_c = \frac{1}{\pi T_0}\left[\frac{\sqrt{r}+1}{\sqrt{r}-1}\right] \qquad \text{For} \tag{1}$$

$$L_2 = \frac{Z_{c0}T_0}{(\sqrt{r}+1)^2} \qquad k \geq 0.95,\; r \geq 50.0 \tag{2}$$

$$C = T_0/Z_{c0} \tag{3}$$

The expression for the group delay time, normalized with respect to its zero frequency value, is

$$\frac{T_g}{T_0} = \frac{(\sqrt{r}-1)^2}{[4\sqrt{r}u^2 + (\sqrt{r}-1)^2]\sqrt{1-u^2}} \tag{4}$$

where Z_{c0} = zero-frequency characteristic impedance of the section; T_0 = zero-frequency time delay in seconds; T_g = group time delay; $u = f/f_c$.

Curves indicating the per cent variation in the group delay time as a function of u in the passband for several values of the parameter (r) are shown in Figure 2. Figure 1 shows the manner in which the delay line, comprised of any number of sections, may be terminated at either end. For the left-end termination the optimum value of b is 2.0. Lines built with this termination have shown remarkably good characteristics, for example, constancy of time delay and smooth line operation.

In applications where the line must have a large number of sections, the Pierce section offers distinct advantages. Only two components are needed per section—one capacitor and a double winding inductor. Its time delay characteristic compares very favorably with other types.

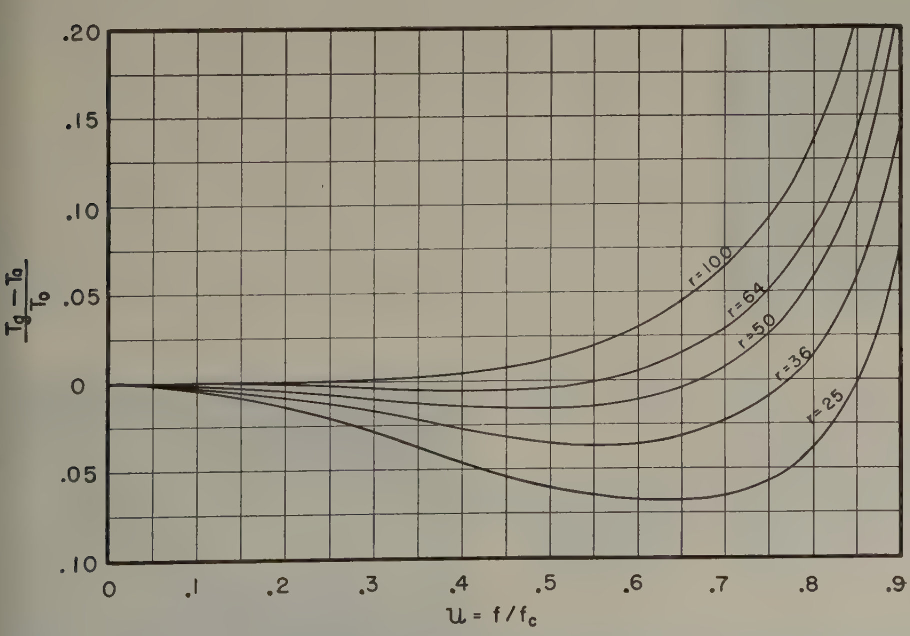

Figure 2. Per cent variation of delay time versus frequency ratio for Pierce unsymmetrical section

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The Modern Flight Simulator

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The modern flight simulator is one of the largest and most complex types of electromechanical analogue computing equipment manufactured in production quantities for use outside the laboratory. Its history, economics, and design are considered here.

THE MODERN flight simulator is designed to provide training for aircraft crews on the ground under safe and controlled conditions. It has been developed from synthetic flying training equipment first used extensively during World War II. The earliest equipment of this nature was the Link Basic Instrument Flying Trainer. It was capable of teaching basic instrument flying and radio procedures. As aircraft operation became more complex, the training problem increased proportionally. Today successful operation of aircraft such as the *F-86*, *F-89*, and *B-47* requires the use of simulation equipment capable of providing effective training in all the operations of these aircraft including engine system, fuel system, hydraulic system, electric and electronic systems, flight characteristics, and radio aids to navigation. The equipment required to satisfy this requirement is extremely complex, often containing as many as 1,000 electron tubes and consuming as much as 35 kw of power. Some examples of these equipments are given in Figures 1 and 2.

It should be emphasized that a flight simulator for training purposes is not a laboratory tool for assisting in dynamic analysis of aircraft flight characteristics. The control inputs which the pilot uses must be identical to those in the aircraft and the computer output displays must be identical to those used by the pilot. The inputs must be statically and dynamically correctly related to the displays in real time so that the pilot being trained may be considered one element in a closed-loop system controlling the aircraft. He is an exceptional type of element in that his transfer characteristics may be modified by experience to improve the over-all system control characteristics. The purpose of the simulator is to provide experience similar enough to the actual flight experience so that the transfer of learning from the simulator to the aircraft situation is maximum.

ECONOMICS

IN ORDER TO obtain some idea of the economic requirement for flight simulators it will be well to examine some comparative costs. Some typical data[1] are given in Figure 3. It will be noted that the direct operating costs of a flight simulator are negligible, for all practical purposes, compared with the direct operating costs of any modern aircraft.

Determining the economic yield of a flight simulator is an extremely complex and arbitrary task for the simple reason that there is no objective measure available for its output, that is, a simulator may be used to increase flight safety, decrease air training time, increase air performance, or to increase the rate of training of flight personnel. It can be seen that none of these products of the simulator can be simply and directly measured. In particular, it is extremely difficult to measure objectively the rate of training of a pilot and/or his proficiency. Steps are being taken in the Human Engineering field to develop objective pilot scoring means. Some of the experimental equipment presently being used by the Aeronautical Medical Laboratory at Wright Air Development Center is shown in Figure 4. This equipment scores and records errors from prescribed variable values which may be adjusted for the particular training problem. Similar equipment is used both in the air and on ground trainers. As many as 20 flight variables may be measured and ten selected for scoring or recording simultaneously. Extensive controlled tests are under way at the University of Illinois Psychology Department under the direction of Dr. A. C. Williams and it is hoped that objective test methods can be developed for determining transfer of training from the simulator to the air. Initial results are encouraging but all the answers are far from known. Until such methods are perfected, the design of a simulator may be on an engineering basis, but its economic evaluation will be an art. For one evaluation see reference 2.

DESIGN

THERE ARE SIX MAJOR SECTIONS into which the design problems encountered in a flight simulator may be divided. Many of these areas pose design problems of much the same nature; however, the relative frequency and importance of these problems vary. For example,

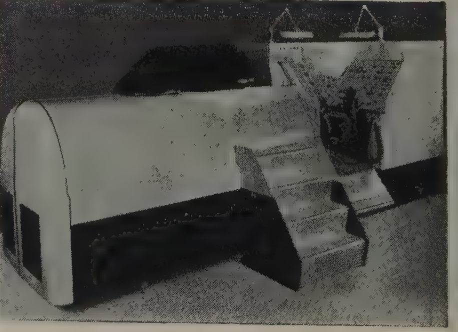

Figure 1. The C-11A jet instrument flying trainer

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Figure 2. The B-47 flight simulator

the following indicates the design phases with the correlated problems most frequently occurring or most important to proper solution:

1. *Flight.* Dynamically accurate integration over relatively short periods, co-ordinate transformation and generation of arbitrary functions.
2. *Engine.* Solutions for arbitrary functions with more than one dimension, $Z=f(X_1Y_1)$.
3. *Radio Aids.* Statically accurate long-term integration, small differences between large numbers and co-ordinate transformation.
4. *Accessories.* Relay circuit problems, proper interlock of all systems for normal and abnormal operation of any one system; discontinuous functions.
5. *Control Forces.* Accurate provision of control moments over wide ranges (1,000–1 or better). Rapid response high-horsepower servo controls, and so forth.
6. *Configuration.* Human engineering for instruction console, computer packaging for minimum space, maximum maintenance availability.

It is not the purpose of this article to discuss detailed design of the simulator nor would space permit. However a small part of the problem may be examined and by its example some idea of the nature of the problem may be obtained. The flight system is one of the most interesting dynamically and one of the most complex parts of the system so it will be examined in more detail.

The aircraft may be considered as a body in space with six degrees of freedom. Since an aircraft has a plane of symmetry, the plane determined by its longitudinal and vertical axes, these freedoms may be considered as consisting of two sets: first, the lateral motions—rolling, yawing, and side slipping; and second, the longitudinal motions—pitching, vertical translation, and forward translation. To keep the problem within reasonable bounds only the longitudinal motions will be considered.

Since the aerodynamic coefficients are normally measured with respect to the wind axis of the aircraft and the total velocity vector is along this axis, it is convenient to use a moving set of axes fixed to the airplane wind axis in arriving at the equations of motion (see reference 3 for a complete treatment of this problem). Making the usual simplifying assumptions, which neglect products of

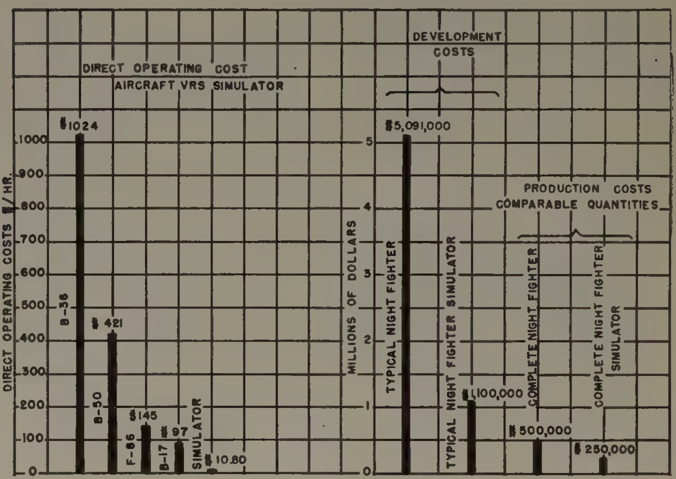

Figure 3. Comparison of aircraft and simulator costs

Figure 4. Air-borne scoring and recording equipment

inertia and changes of moments of inertia, the three equations of motion are

$$\Sigma F_x = m\dot{V} \tag{1}$$

$$\Sigma F_z = -mV\dot{\gamma} \tag{2}$$

$$\Sigma M_y = \dot{q}_1 I_y \tag{3}$$

Since the interest is in the system problem and not the aerodynamic problem, which is covered elsewhere in the

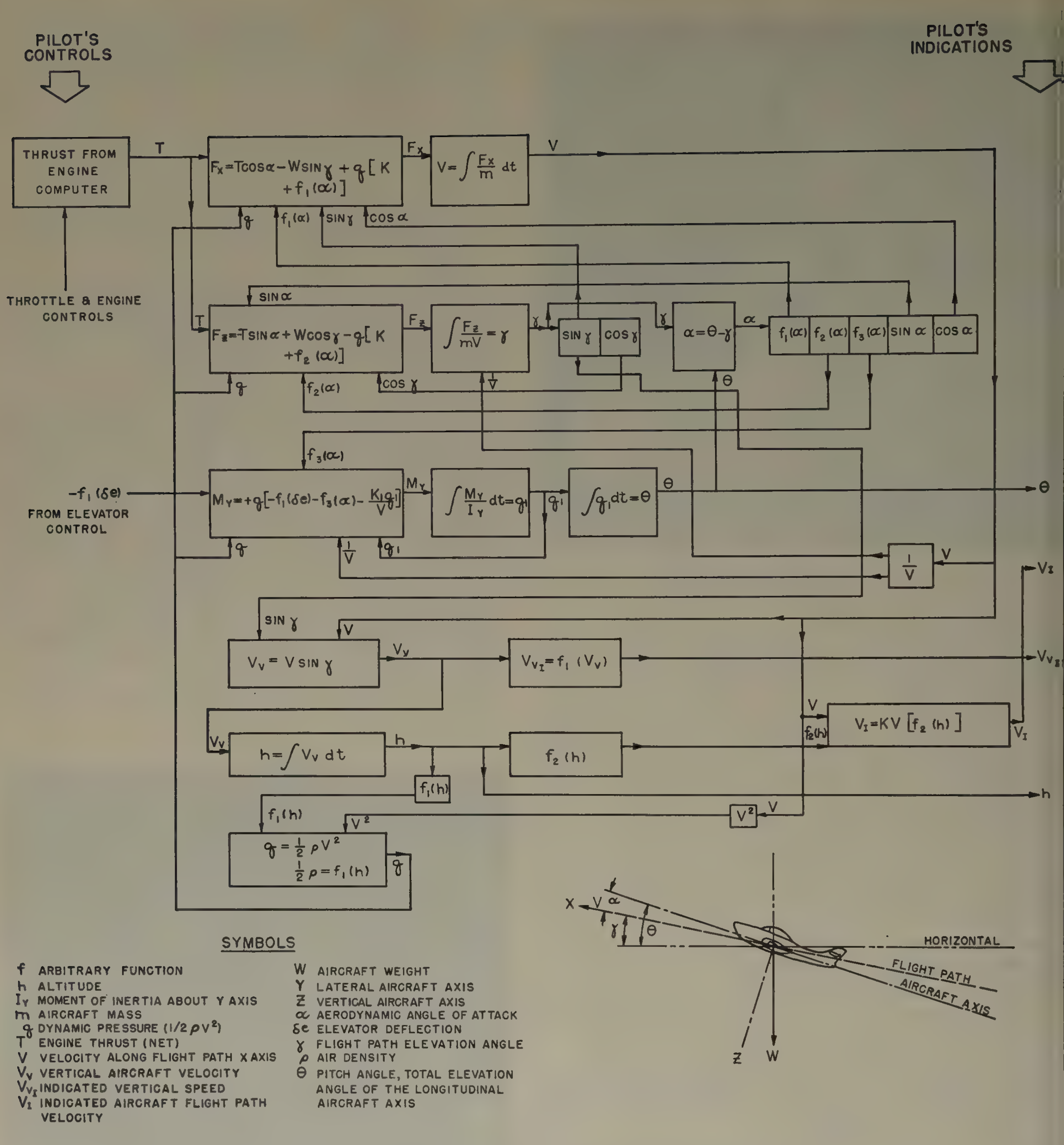

Figure 5. Functional block diagram with simplified pitch system

literature, consider the functional block diagram, Figure 5, for a simplified pitch system.

For the sake of system simplicity, only the major variables have been shown. The effects of wheels, dive brakes, flaps, and wing tanks have been omitted. Constants of integration and proportionality constants have been neglected also and mass has been considered to be constant. Even so, it is a reasonably complex system with several loops inside of loops and a large number of operations to perform.

It is the writer's opinion that a functional block diagram of this nature can be of major assistance in designing complex computer systems. Detailed inspection of a diagram like this often will demonstrate ways of reconnection which will simplify the problem and reduce the total number of operations which must be performed in the computer. In other words, it is of major value in analyzing the mathematics of the problem for rearrangement yielding optimum mechanization. In addition, specifications for individual computer components such as summing amplifiers, integrators, mechanical subtraction means, potentiometers, and so forth, may be conveniently analyzed with

respect to system requirements such as resolution and tightness.

The system shown has dynamic characteristics typical of an aircraft, that is, two modes of response—one with a rather long period and the second, and usually most important, much shorter. The long period mode is the familiar phugoid mode. This mode arises if we assume an increment change in F_x caused, for example, by a thrust change T. Without attempting rigorous examination, if the airplane is speeded up with no elevator position change, the dynamic pressure q will increase, increasing the total lift and the airplane will pitch upward. As the aircraft pitches upward, the component of the weight acting along the flight-path axis tends to decelerate the aircraft toward the original speed condition. Most aircraft are slightly stable in this mode but the damping factor is very low and the computer must be extremely accurate to reproduce this characteristic realistically. As a matter of fact, slight errors in the computer can cause enough additional phase shift in the loop to cause instability where the aircraft would be normally stable. The second important mode is the one occurring where a disturbance is made by the elevator in the Y-axis moments. In this case the frequency is much higher and most aircraft, of necessity, are quite well damped in this mode of oscillation. As a matter of fact it is so rapid that it can be assumed that there is no air speed change and therefore no change in q and the factors involved are an increase in angle of attack to the point where the pitching moment developed by the wing equals the added moment produced by the elevator, the damping term of the system being determined by $K_1(q_1/V)$. Typical response characteristics for a simulator are shown in Figure 6.

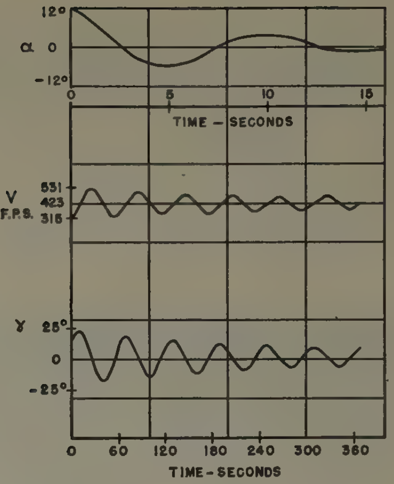

Figure 6. Pitch dynamics

In considering the mechanization of such a functional block diagram the operations to be dealt with are (*a*) integration, (*b*) addition or sign inversion, (*c*) multiplication, (*d*) generation of arbitrary functions, and (*e*) trigonometric resolution. Taking these operations in order, let us examine the means available. All have been covered in the literature, so their detailed design will not be discussed, and only their outstanding advantages will be indicated.

(*a*). Integration may be accomplished by the Miller integrator circuit where a high-quality capacitor is placed in the feedback circuit of a d-c amplifier. With good components and a stable amplifier, the output voltage may be made to increase linearly with time and at a rate proportional to the input. A second method is to use a generator whose output voltage is accurately proportional to speed in a velocity servo system. The error signal in this servo system is the difference between the control signal and a generator signal on the servo motor shaft. The generator must have an output signal which is linear with respect to shaft speed and have a minimum zero-speed signal.

(*b*). Addition is most practically accomplished by a summing amplifier circuit where the output signal is fed back to the junction point of the parallel-connected resistors adding the variables involved. Alternately, shaft rotations may be added in mechanical differential mechanisms.

(*c*). Multiplication is not easily accomplished by any simple electronic means having the required accuracy, simplicity, and stability, and in simulator computation multiplication is nearly always accomplished by potentiometers on shafts.

(*d*). The generation of arbitrary functions is also readily accomplished by either shaped, tapped, or loaded potentiometers on shafts representing the variables.

(*e*). Trigonometric resolution may be accomplished either by magnetic resolvers or by resistance resolvers, the choice between these two depending on whether direct or alternating current is being used as the variable analogue in the circuit and resolution required in the operation.

It will be noted that there are many other ways of accomplishing these operations which are not mentioned here. However, it should be emphasized that a simulator, as can be seen from the functional block diagram, is extremely complex and contains many operations in sequence; hence only methods which can be made extremely reliable, that is, closed-loop methods or methods that depend on very accurate and stable components, may be chosen if the over-all system reliability and accuracy is to be within reason. Methods depending upon tube characteristics, for example, are completely unsuitable since tube selection and/or adjustment for particular tube characteristics cannot be afforded in a system with this complexity.

Making use of the foregoing methods, a mechanized diagram for the functional block diagram, Figure 7, has been derived. It will be noted that the velocity servo method for integration has been chosen since there are multiplication operations to perform on all of the variables involved and hence there is need of shaft rotations. The capacitor integration method would have provided only voltage signals. The shaft rotations are now also available for pilot's indications. Had capacitor integration been used, either a voltmeter movement or a servo would be required for this purpose.

The mechanism now may be considered as one element in a totally closed loop, the pilot being a second element in the loop; that is, by observing the indicators at the

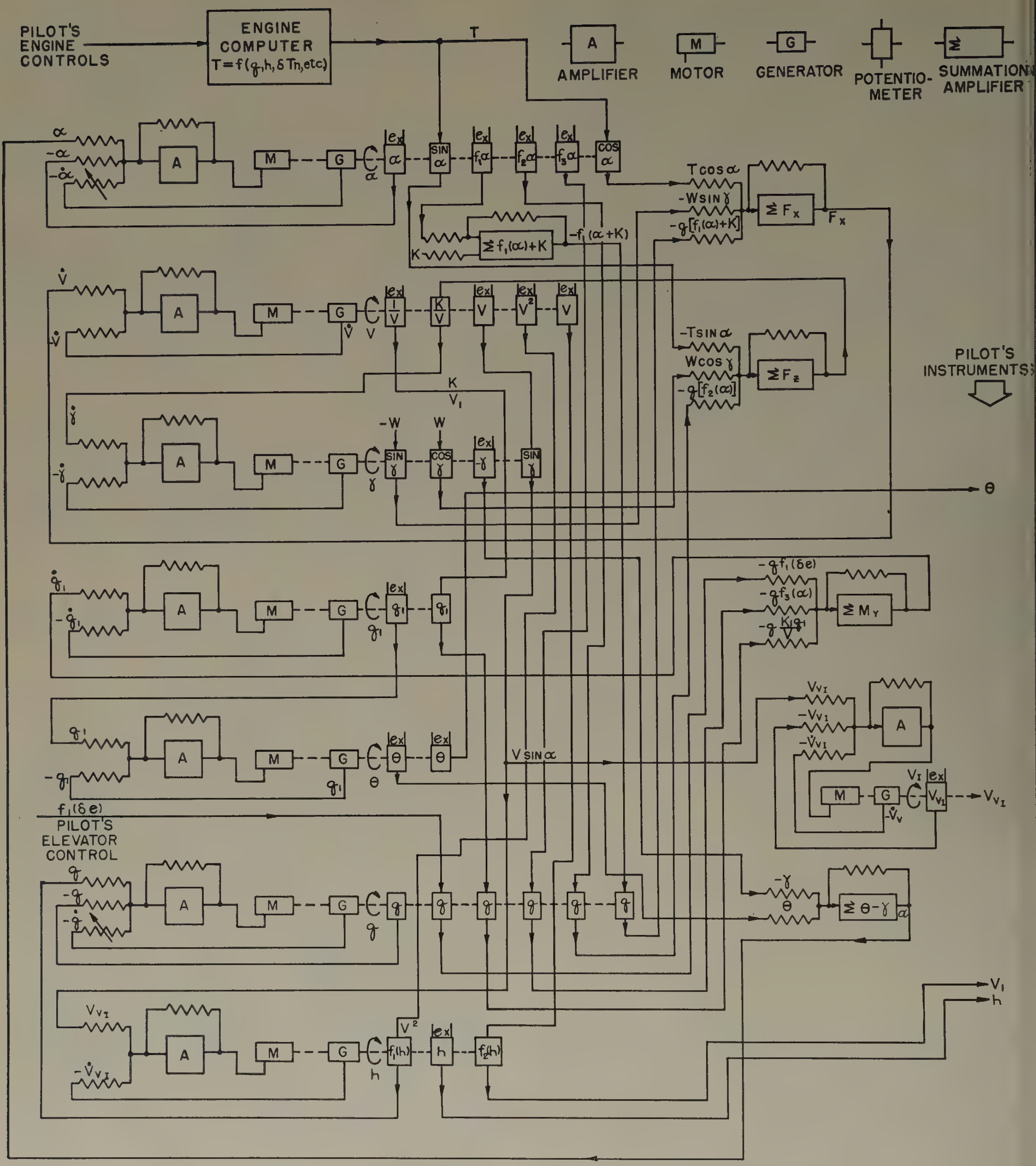

Figure 7. Mechanized block diagram with simplified pitch system

output end, the pilot operates his controls at the input end in such a way as to maintain these indicators on the values he desires. A measure of his performance is how accurately he is able to do this and how rapidly he is able to go from one point to another or from one set of steady-state conditions to a new specified set of steady-state conditions. That this operation is not necessarily easy may be seen from the response characteristic of the system as given in Figure 6 and Figure 7.

For example, note that in controlling vertical speed the pilot moves the elevator to change the angle of attack which in turn responds to his control as demonstrated by the short-term longitudinal response as shown in Figure 6. The angle of attack then controls rate of change of flight-path

elevation angle and for small angles this produces a proportional true vertical speed. However, an exponential time lag is inserted between true vertical speed and the pilot's indications by the instrument. While the pilot is accomplishing the problem described, he has disturbed the system in its phugoid mode and this is reflected, in turn, in a changed vertical-speed response. As a matter of fact it is practically impossible for the pilot to control vertical speed by reference to the vertical-speed indicator alone; he must refer to the attitude gyroscope for pitch and other instruments so that he can close the loop in a stable manner.

Having considered the general problem of mechanization of equations, there are several other design problems worthy of consideration. Serviceability is an extremely important one since this equipment is designed to be used, not in the laboratory, but in the field. Several steps may be taken to improve serviceability. First and most important, it is necessary to choose only the most reliable

Figure 8. Computer slide rack showing ease of accessibility

methods in computation. Self-checking or closed-loop circuits must be used wherever feasible. Each individual component must operate well within its limits and must be thoroughly tested for life, stability, and reliability. Second, it is important to make all equipment in the system readily accessible. This may be accomplished as shown in Figure 8 by mounting computer amplifiers and chassis on slide racks so that they are available for maintenance without disconnection from their computer circuits. In addition, each variable shaft may be equipped with a dial so that the value of the variable registered in the computer may be read at any time right at the computer. It is also convenient to arrange each servo-driven shaft with a "Manual-Automatic" switch so that that particular computer may be taken out of the circuit and operated manually to any desired variable value during test operations.

In addition to serviceability, there are configuration design problems which must be given extensive consideration. In most simulators the number of controls which the instructor must operate is extremely large. The instructor's job is to determine station locations and characteristics of all radio transmitters being simulated and to insert troubles simulating failures of various types in the aircraft when the problem syllabus calls for them. In addition, the instructor, of course, must monitor the student's performance by observing the flight-path recorders. These may include not only ground track but localizer and glide-path recorders as well as elevation recorders. Figure 9 shows a typical arrangement where the instructor may perform this operation without moving

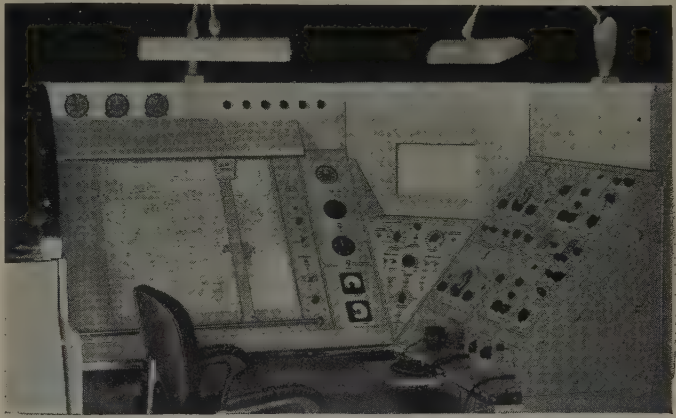

Figure 9. Instructor's station in C-11A jet instrument flying trainer

from his chair. In general, it is helpful to use a temporary mock-up which may be tested for various operations by the instructor in order to arrive at a satisfactorily engineered control station. Location and readability of dials is important as well as shapes and directions of rotations on knobs. Everything possible is done to make the instructor's job easy by having the computing equipment fully automatic. However, this still leaves a large number of operations which must be performed at the discretion of the instructor; that is, operations which he must be able to control in order to establish the desired training program.

CONCLUSIONS

The history of the modern flight simulator has been one of rapid technical development and increasing complexity. Its importance increases with each increase in aircraft complexity. The most reliable and accurate means available in analogue computer and servomechanism techniques are required for satisfactory simulator performance. Rapid strides are being made in techniques of experimental psychology which, it is hoped, will yield analytic data on the contribution of flight simulators to air training and safety. Meanwhile, the evaluation of simulators rests with the training experts. These experts are practically unanimous in the opinion that simulators are essential to support adequately the present development of commercial and military air power.

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New 14.4-Kv Indoor Compressed Air Circuit Breaker

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IN 1939–40, soon after compressed air circuit breakers were first introduced in this country, interest in these circuit breakers by central station users was high and it remained so.

Much has been learned in the intervening years. Thousands of these circuit breakers have been manufactured. The resulting evolution has brought forth many significant changes in design concepts. The designer realized all too soon that previously developed ideas relating to the use of compressed air in air brakes, injectors, and the like, could not be applied to meet the exacting requirements of circuit breakers unless certain changes were made. It was necessary to develop new application techniques before the compressed air circuit breaker could be the dependable circuit interrupter that it is today. Probably the end results on these techniques generally are of more interest to the ultimate user rather than the details relating to their transition. For this reason the author has presented a new modern circuit breaker and the design points of component parts developed from field and manufacturing experiences on this type of circuit breaker.

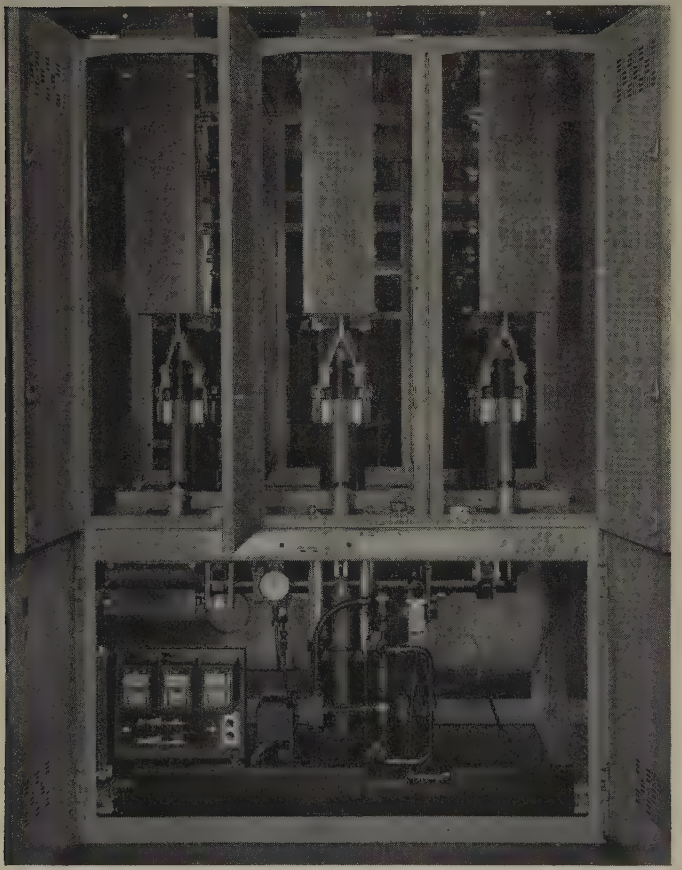

Figure 1. New design of 1,500,000-kva 14.4-kv 2,000-ampere compressed air circuit breaker

Figure 1 shows a modern compressed air circuit breaker having an interrupting rating of 1,500,000 kva at 14.4 kv with a continuous current rating of 2,000 amperes. This circuit breaker features reduced space requirements over the same design of 10 years ago. For instance, the width has been reduced from 81 inches to 62 inches, and its weight from approximately 6,000 pounds to 4,200 pounds. These gains were not made at the expense of any functional or electrical features. Maintenance requirements were considered throughout the over-all design, and the new design incorporates equal or more accessibility of all component parts for maintenance or inspection. Through redesign a circuit breaker has resulted that has been tested and demonstrated to be more than adequate for its electrical requirements and interrupting rating, that weighs less, requires less space, produces greater closing effort, is more accessible for maintenance, and requires less maintenance in that adjustments and air leakage have been reduced to a minimum.

The general circuit breaker arrangement has remained essentially unchanged. The mechanism and control compartment is metal-enclosed at ground potential and separated from the high potential compartment. An operating pressure of 150 pounds per square inch and straight-line flow of air from the blast valves to the interrupters have been retained.

In the high-voltage compartment, a new design of pole unit is used which features new contacts of reduced width and essentially free of contact adjustment and alignment problems. The arc chutes are narrower and of improved design being longer to incorporate more cooling of arc gases and elimination of a muffler.

A new mechanism has been provided along with new types of shock absorbers. These, in combination with a functional exhaust valve, permit maintaining the closing force of compressed air until the circuit-breaker contacts are closed fully or they permit immediate reopening on a fault operation without retardation due to air previously used on closing. The shock absorbers are worked over-toggle so that maximum resistance is applied when needed to reduce rebound and impact.

This new design is applied throughout a range of circuit-breaker ratings from 1,000,000 kva to 2,500,000 kva, 14.4 kv to 34.5 kv, and 1,200 amperes continuous current rating to 5,000 amperes.

Digest of paper 52-173, "A New 14.4-Kv Indoor Compressed Air Circuit Breaker," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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D-C Overpotential Testing on High-Voltage Generators

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OVERPOTENTIAL TESTS are applied to electric apparatus to demonstrate the ability of the insulation to withstand a specified voltage for a certain period of time. Industry standards accept overpotential tests as the only reliable tests for the dielectric level of machine insulations. Practically all recognized standard overpotential tests on electric machinery are made with alternating current. During the past several years, investigation of d-c overpotential testing indicated basic advantages over a-c testing and that direct current could be used as a satisfactory overpotential test on large high-voltage machines.

Significant advantages to be obtained using d-c overpotential tests are: 1. voltages which are equally searching for defects and physical damage are far less damaging than the equivalent a-c voltages; 2. the slope of the voltage endurance curve is such that the time of voltage application is not nearly so critical with direct current as with alternating current; and 3. the problems associated with d-c testing of large equipment are simpler, as a testing device with limited capacity can be used. Experience in testing many specimens of conventional insulation and a-c and d-c breakdown tests on old stator windings served to help establish a ratio of direct current to alternating current (rms) for equally searching effect for common types of insulation faults. On the basis of these investigations, a ratio of direct current to alternating current (rms) of 1.6 has been proposed for maintenance tests on large high-voltage rotating machines.

Previous limitations of d-c testing were: 1. different stress distribution with direct current than with alternating current; 2. lack of suitable high-voltage d-c test equipment; and 3. the wide variations of d-c to a-c peak voltage breakdown of solid insulations. Improvements in the last decade in high-voltage rectifying tubes have eliminated largely the problem of equipment. A main objection to d-c testing is that stress distribution of a-c apparatus is determined by leakage resistance when direct current is applied and by capacitance when alternating current is applied. The stress distribution with a d-c test may, therefore, differ greatly from that in normal service. However, the stress on end windings with direct current appears to build up slowly enough so that it does not constitute a major problem with the usual times that such tests are applied. The variation in the d-c and a-c peak breakdown voltages of solid insulation systems, although very controversial, should not limit the acceptance of d-c overpotential testing. Investigation of specific insulating systems will enable proper application of d-c test voltages to give assurance of the absence of specific types of insulation faults.

D-c overpotential testing has been used for preliminary winding tests on high-voltage generator windings. Manufacturer's preliminary winding tests are directed toward weeding out defective insulation that may result in coil failures during final test. A direct voltage is required that has equal or greater destructive effect than the final 1-minute a-c test voltage. For adequate d-c test voltages for preliminary winding tests of conventional 13.8-kv generators, a d-c tester of about 75 kv is required. At these high direct voltages, voltage recovery characteristics of generator windings indicate an appreciable recovery voltage is possible if the winding is not grounded properly after test. Voltage recovery characteristics of several high-voltage windings have been measured. Results indicate a winding should be grounded at least 60 minutes after a high-voltage d-c test has been applied. Shop acceptance of d-c testing has been good and d-c tests have replaced a-c tests except for the commercial final winding test in large high-voltage generators.

Field acceptance and maintenance tests long have been a problem because of the size of a-c test equipment and the power supply required. Overpotential tests are the only means of providing assurance that the winding insulation has a certain minimum insulation level. Suitably selected values of direct current are equally as searching for likely types of insulation weakness with the expectancy of small or negligible destructive effect on good insulation. D-c overpotentials appear to be fundamentally advantageous for maintenance tests in addition to economic advantages. During the last 2 years, many generators have had d-c overpotential maintenance tests applied to the stator windings. For 13.8-kv machines, the usual d-c overpotential test was 30 kv for 1 minute. In no case has it failed to pick out serious cases of insulation weakness.

About 4,000,000 kva of high-voltage generating equipment has been inspected in the field and d-c overpotential tests have been made to give assurance of adequate insulation level. About 1,000,000 kva of generating equipment has been tested with direct current in the Westinghouse factory. The success and general acceptance of d-c overpotential testing has been widespread both in the shop and in the field.

While much fundamental investigation of d-c versus a-c testing will be accomplished by many individuals in the next few years, there can be little doubt that d-c overpotential testing will be expanded where applicable to take advantage, in addition to fundamental advantages, of its lower initial cost and lower operating cost, with more informative test results.

Digest of paper 52-151, "D-C Overpotential Testing Experience on High-Voltage Generators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The author gratefully acknowledges the assistance of G. L. Moses and J. S. Johnson, Westinghouse Electric Corporation, for their suggestions and contributions.

Questionnaire Results Concerning Current Field Practices in Electrical Tests on Dielectrics

AIEE SUBCOMMITTEE REPORT

THE ACTIVITIES of the Subcommittee on Electrical Tests on Dielectrics in the Field, established by its parent committee in 1940, are described in its scope as follows: "to investigate and evaluate the dominant features of instruments and techniques suitable for testing the electrical insulation of power apparatus in the field, to sponsor technical publications, and to suggest standard procedures for testing in the field."

As one step towards these objectives, the subcommittee distributed a questionnaire to the electric power industry in United States and Canada. The questionnaire consisted of four questions which, in the interests of brevity, are summarized as follows:

Question 1. Do you make electrical tests on dielectrics in the field?

Question 2. What types of a-c insulation tests do you make in the field?

Question 2 consisted of 12 tabular forms, one for each of the common types of power apparatus (see Table I for list). Each form listed the four common types of a-c field tests: dielectric loss and power factor, voltage withstand, voltage distribution, and corona detection; and asked for such data as test voltage and frequency, time of voltage application, and electrical characteristics measured, for the tests used. Other spaces in the forms asked for an evaluation of the test results, an estimate of the number of tests, and the reasons for which the tests were made.

Question 3. What types of d-c insulation tests do you make in the field?

The third question was the same as the second but listed the four types of d-c field tests: insulation resistance, dielectric absorption, voltage withstand, and corona detection; and asked for data similar to that in Question 2.

Question 4. The fourth question asked for information on any other field tests not covered by Questions 2 and 3.

Table I. Number of Power Systems Using Test Methods Listed on Insulation of Apparatus Shown

A-C Test Method: Test Voltage, Kv	Test Frequency, Cycles Per Second	Electrical Characteristics Measured*	Line Insulators	Bushings	Potheads	Power Transformers	Distribution Transformers	Instrument Transformers	Lightning Arresters	Insulating Liquids	Carrier Current Capacitors	Cables	Rotating Machinery	Circuit Breakers
			Number of Power Systems											
10	60	I&W	24	99	50	98	24	95	69	77	75	40	22	90
10	60	C&DF		1		1						1		
10	63.5	C&DF		3										
10	70	C&DF		7		3		1	2	1	3			5
2.5	60	I&W		38	4	31	2	31	23	23	20	2	1	29
80–100 volts	60	C&DF		11	1	2	4	2			3	2	2	1
30 volts	60	C&DF		1						1				
Voltage withstand			7	6	13	20	14	15	5	112	3	32	31	9
Voltage distribution			62	3					1				1	
Corona detection			1	4	1		1	1	1				9	1
D-C Test Method														
Insulation resistance			4	20	31	57	16	33	13	2	6	79	91	19
Dielectric absorption					3	27	3	6				25	56	1
Voltage withstand			2	1	32	7	4			1		52	25	
Corona detection													7	

* I&W = current and watts; C&DF = capacitance and dissipation factor.

SUMMARY OF RETURNS

THE QUESTIONNAIRE was sent to 183 utilities and service companies representing 241 operating systems in the United States and Canada whose combined generating capacity totalled over 65 million kilowatts. (Figures are based on the 1950 McGraw Central Station Directory.)[1] There were 117 replies received, covering 129 of the 183 utilities, and representing 186 operating systems with a total generating capacity of about 52 million kilowatts, or 80 per cent of the total canvassed. The 54 systems which did not reply represent 13,399,906 kw capacity.

The replies received were distributed fairly broadly and evenly so that the data were secured from a large and very representative cross section of the power industry. The number of systems contacted, classified by generating capacity and geographical location, is shown in Table II.

DISCUSSION OF INDIVIDUAL QUESTIONS

Question 1. "Do you make electrical tests on dielectrics in the

Full text of paper 51-186, "Results of a Questionnaire Covering Current Practices in Electrical Tests on Dielectrics in the Field," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Published in AIEE *Transactions*, volume 70, part I, 1951, pages 986–9.

This report was prepared by members of AIEE Subcommittee on Electrical Tests on Dielectrics in the Field. Personnel of the subcommittee at the time of this survey were: F. C. Doble, *chairman;* W. G. Amey, D. L. Brown, A. L. Brownlee, E. B. Curdts, C. L. Dawes, W. F. Dunkle, I. G. Easton, W. N. Eddy, J. G. Ford, I. W. Gross, E. S. Lee, W. N. Lindblad, H. C. Marcroft, G. M. L. Sommerman, E. R. Thomas, L. Wetherill.

This report summarizes the current practices in field testing of high-voltage insulation of 129 electrical utilities and service companies, representing 52 million kilowatts of generating capacity in the United States and Canada.

field?" was answered "Yes" by 169 systems; "No" by 13; "Not in manner described" by two; and "Program not sufficiently developed to answer" by two.

Of the 169 systems doing field testing, two limit their programs to tests on insulating oil only, four to d-c and two to a-c tests on rotating machinery, one to tests on oil and rotating machinery, and three to the latter plus d-c tests on power transformers. The balance of 157 systems have programs of field testing which are summarized in Table II. This table lists the different types of test methods reported in the replies tabulated against the 12 common types of power apparatus. It shows the number of power systems utilizing each type of test for each type of apparatus.

A large proportion of power systems employ both a-c and d-c tests in various combinations.

Thirteen systems use a-c tests only, nine use d-c tests alone (of which four test rotating machinery only), and 73 use only a-c tests for the insulation of apparatus other than cables and rotating machinery. The total number of systems using each type of test and the number of apparatus types to which they apply them are shown in Table III. It should be noted that of the 129 systems shown as using the alternating voltage withstand test, 112 use it on insulating oil, 69 of which use it for this purpose alone.

Questions 2 and 3. The replies to Questions 2 and 3 have been summarized in Table IV. This table consists of 12 sections, one for each type of power apparatus. In each section are shown the various types of tests reported to be in use on that type of apparatus; the number of repliers using each test method; the range of manufacturer's voltage ratings of apparatus to which the tests are applied; the total estimated number of tests made by each method classified as "Good," "Fair," "Poor," or "No Rating," according to the evaluation of each test method by each power system reporting; and the reasons for which the tests were made.

It should be noted that the classification of test results refers only to the rating of the test method by each user and not to the physical condition of the test specimen. Thus, the number of tests appearing in the "Good" column indicates the extent to which a test method was considered successful in detecting good, deteriorated, or bad insulation; it does not show the number of good or defective insulations found by that test method.

A noteworthy result was the lack of variation in test method with change in voltage rating of the test specimen. Although space was provided on the questionnaire to show such change in method with change in voltage rating, no significant variations were reported. While test voltages varied with the insulation voltage rating for some d-c insulation resistance tests and all voltage withstand tests, there was not enough unanimity of practice to permit tabulation of these data.

Question 4. This question asked for data on field tests other than those covered by previous questions. In replying to this question a few companies listed nonelectrical tests on insulation and tests on materials other than insulation. Since these are outside the scope of the questionnaire, they are not included in the summary. Answers which omitted significant information, such as types of insulation tested or method used, also are not included. Only two companies reported the number of tests and their value.

Low-Voltage Cable (600 volts and below including control and instrument cable): Ten companies use d-c insulation resistance on this type of insulation and three

Table II. Power Systems Contacted, Classified Geographically by AIEE Districts and by Generating Capacity

Generating Capacity, Kw in Thousands	1 North Eastern	2 & 3 Mid East. & NYC	4 Southern	5 & 6 Midwest	7 South West	8 & 9 Pacific & North West	10 Canada
	Reporting Number of Power Systems in each AIEE District						
0–49	21	10	7	17	1	2	4
50–99	2	5	4	6	3	1	2
100–499	12	14	8	16	11	7	3
500–999		5	3	5	1	2	3
1000–up	1	3	2	2		2	1
	36	37	24	46	16	14	13
	Not Reporting						
0–49	1	1	1	4	2	2	
50–99	2	1	1	2	2		2
100–499		3	5	8	5	4	2
500–999	1	3	1				
1000–up				1			1
	4	8	8	15	9	6	5

Table III. Applicability of Various Test Methods

A-C Test Method	Total No. of Systems Using	Cumulative Number of Apparatus Types Tested by No. of Systems* 1	2	3	4	5	6	7	8	9	10	11	12
10-kv 60-cycle I&W	99	99	99	98	98	94	86	80	54	33	21	1	
10-kv 60-cycle C&DF	1	1	1	1									
10-kv 63.5-cycle C&DF	3	3											
10-kv 70-cycle C&DF	7	7	5	5	2	1	1	1					
2.5-kv 60-cycle I&W	39	39	38	29	25	24	23	22	3	1			
80–100-volt 60-cycle C&DF	17	17	9	2									
30-volt 60-cycle C&DF	2	2	1	1									
Voltage withstand	129	129	60	38	19	10	6	4	2	1			
Voltage distribution	63	63	3										
Corona detection	13	13	2	1	1	1	1	1					
D-C Test Method													
Insulation resistance	134	134	79	55	43	25	15	12	6	3	1		
Dielectric absorption	70	70	32	15	5								
Voltage withstand	60	60	40	25									
Corona detection	7	7											

* Column number headings do not correlate with Table II. For example: Under "5" the 10 in line 8 means that ten companies tested at least five of the types of apparatus insulation listed in Table II by the alternating voltage withstand method.

I&W = current and watts; C&DF = capacitance and dissipation factor.

Table IV

	Test Method	No. of Users	Voltage Ranges Tested (Kv)	Good: No. of Systems	Good: No. of Tests	Fair: No. of Systems	Fair: No. of Tests	Poor: No. of Systems	Poor: No. of Tests	No Rating: No. of Systems	No Rating: No. of Tests	Prevent Service Failures	Follow Progressive Deterioration	Schedule Maintenance	Accept New Equipment
				Number of Systems and Estimated Number of Tests in Past Year With Value of Results Rated:								Number of Systems Testing to:			
	Section 1. Tests on Line Insulators														
a-c	10 kv 60-cycle I&W	8	5–230	8	2,908					1	100	7	4	1	3
a-c	Voltage withstand	6	22–138	3	5,099	1	300			3		1	1	1	4
a-c	Voltage distribution	30	5–230	23	1,280,352	2	1,000	1	100	4		24	8	10	3
d-c	Insulation resistance	5	5–230	1	thousands	1	1,150	1		2	21	3	2	2	1
d-c	Voltage withstand	2		2	22							1		1	2
	Section 2. Tests on Bushings														
a-c	10-kv 60-cycle I&W	44	2.3–220	39	73,401	2	15			6	100	38	38	18	29
a-c	10-kv 70-cycle C&DF	6	12–220	5	3,867	1	300					5	5	4	5
a-c	2.5-kv 60-cycle I&W	12	4–220	11	7,682	1	300					9	8	6	7
a-c	80–100-volt 60-cycle C&DF	7	5–230	3	163	2	42			2		1	1		2
a-c	Voltage withstand	6	2.3–220	5	1,010	1						3	3	2	6
a-c	Voltage distribution	3	5–230	2	3,650	2	12					3	3	1	1
a-c	Corona detection	4	2.3–220	2	56	1	6			1		3	3	2	2
d-c	Insulation resistance	19	4–220	7	4,228	10	30,213	1		2		12	5	6	9
	Section 3. Tests on Potheads														
a-c	10-kv 60-cycle I&W	29	4–69	21	2,397	4	124			4	35	25	24	10	10
a-c	2.5-kv 60-cycle I&W	4	2.3–115	3	820	1	140					4	3	4	3
a-c	Voltage withstand	7	2.4–34	5	46					2		2	1		6
a-c	Corona detection	2	2.4–15	2	26							1	1	1	1
d-c	Insulation resistance	24	4–69	8	904	7	851	2	312	7	50	15	10	6	10
d-c	Dielectric absorption	3	7.5–34.5			3	320					3	2		2
d-c	Voltage withstand	7	4–115	4	189	2	810			1		4			4
	Section 4. Tests on Power Transformers														
a-c	10-kv 60-cycle I&W	43	2.3–230	38	7,874	3	34			3	3	36	37	20	27
a-c	10-kv 70-cycle C&DF	2	13–132	1	112	1	6					2	2	2	2
a-c	2.5-kv 60-cycle I&W	11	4–220	11	807							10	8	8	8
a-c	Voltage withstand	12	2.4–220	10	767	1	40			1		6	5	2	10
d-c	Insulation resistance	39	5–230	18	4,507	9	3,022	3	465	9	34	23	13	9	19
d-c	Dielectric absorption	14	5–230	7	257	3	22			4	25	9	4	2	12
	Section 5. Tests on Distribution Transformers														
a-c	10-kv 60-cycle I&W	8	2.3–115	7	1,478	3	225					6	6	2	4
a-c	2.5-kv 60-cycle I&W	2	25–66	2	1,512							2	2	1	2
a-c	Voltage withstand	12	2.4–14.4	6	8,483	2	3,575	2	792	2		4	1	4	4
d-c	Insulation resistance	12	110 v–66 kv	5	5,705	4	1,158			3		5	3	4	4
	Section 6. Tests on Instrument Transformers														
a-c	10-kv 60-cycle I&W	42	2.4–230	37	6,230	1	25			4	27	36	32	19	24
a-c	2.5-kv 60-cycle I & W	8	2.5–140	7	414					1		7	6	7	6
a-c	Voltage withstand	10	2.4–220	7	1,171	1	10			2		6	2	2	7
d-c	Insulation resistance	21	110 v–220 kv	10	19,895	4	1,722	1	150	6		11	7	5	12
d-c	Dielectric absorption	4	5–230	1	20	1	2			2			1		3
	Section 7. Tests on Lightning Arresters														
a-c	10-kv 60-cycle I&W	31	3–230	24	3,516	4	646	1	1	3	30	28	19	12	15
a-c	10-kv 70-cycle C&DF	2	34.5–132	1	21	1	3					2	1	1	1
a-c	2.5-kv 60-cycle I&W	6	5–132	1	500	2	51	1	25	2	8	3	3	2	1
a-c	Voltage withstand	4	3–69	3	1,150					1		4	2	2	3
d-c	Insulation resistance	7	12–132			3	183	2	1018	2		5	3	2	4
	Section 8. Tests on Insulating Liquids														
a-c	10-kv 60-cycle I&W	35	All	28	9,850	8	362			3		30	26	18	14
a-c	2.5-kv 60-cycle I&W	7	All	7	1,795							5	4	3	4
a-c	Voltage withstand	64	All	41	77,800	3	6,175	1	200	19		49	38	35	39
d-c	Insulation resistance	2	22–132	2	145							1	2	1	1
	Section 9. Tests on Carrier Current Capacitors														
a-c	10-kv 60-cycle I&W	26	15–230	22	648	1	2			3	10	21	16	8	12
a-c	2.5-kv 60-cycle I&W	3	66–132	2	8					1	5	3	2	2	1
a-c	Voltage withstand	3	0–230	2	25					1		1	1		3
d-c	Insulation resistance	5	33–161	2	8					3	5	1	1		4
	Section 10. Tests on Cables														
a-c	10-kv 60-cycle I&W	19	4–34.5	10	2,016	8	868			2	6	16	10	5	9
a-c	2.5-kv 60-cycle I&W	2	2.3–19	1	15	1	70					2	2	1	2
a-c	100-volt 60-cycle C&DF	2	2.4–69	1	1	1	1					1	1		2
a-c	Voltage withstand	16	2.4–69	7	538	3	17	1	6	6		3	2	1	10
d-c	Insulation resistance	45	220v–138 kv	19	21,936	12	1,451	4	212	10	48	25	20	9	23
d-c	Dielectric absorption	13	2.3–34.5	2	236	9	305			2	1	9	8	2	10
d-c	Voltage withstand	23	600v–138 kv	19	5,029	2	72			2		11	7	6	15
	Section 11. Tests on Rotating Machinery														
a-c	10-kv 60-cycle I&W	9	4–13.8	4	56	3	14			2	5	6	5	3	5
a-c	100–120-volt 60-cycle C&DF	2	7–13.8			1	8			1		1	1		1
a-c	Voltage withstand	18	2.3–15.5	11	86			1		6		4	4	3	7
a-c	Corona detection	4	6.9–13.8	2	16	1	1			1	5	3	3	1	2
d-c	Insulation resistance	56	125v–22 kv	25	21,347	12	719	1	11	18	15	31	24	15	25
d-c	Dielectric absorption	32	250v–22 kv	16	873	9	448	2		5	17	23	22	9	19
d-c	Voltage withstand	4	2.3kv–15kv	2	70	1	5			1		3		2	1
	Section 12. Tests on Circuit Breakers														
a-c	10-kv 60-cycle I&W	43	5–230	37	6,343	2	36			4		34	29	17	24
a-c	10-kv 70-cycle C&DF	4	23–161	2	229	1	10			1		4	4	4	2
a-c	2.5-kv 60-cycle I&W	10	5–115	9	1,625					1		7	7	7	7
a-c	Voltage withstand	7	4.8–220	5	204	1	20			1	20	2	1		5
d-c	Insulation resistance	15	0–220	10	4,550	2	240			3		9	7	6	8

I&W = current and watts; C&DF = capacitance and dissipation factor.

companies use withstand tests of 1,000 to 1,100 volts alternating current for one minute.

Two companies reported the use of a continuous ground indicating device.

Switch sticks and hot line tools: Two companies use dielectric loss measurements with watts and current measured at 10 kv, alternating current, 60 cycles. One of these reported 70 to 80 tests per year. Another company uses 2,500-volt insulation resistance at one minute.

SUMMARY OF RESULTS

THE RESULTS of the questionnaire may be summarized briefly as follows:

1. Field testing of high-voltage electrical insulation is done by more than 85 per cent of the reporting power systems.
2. The a-c dielectric loss and power factor test is the most widely accepted test method: 139 systems using equipment operating at 2.5 to 10 kv, 60 cycles, and 29 systems using equipment of lower voltages or different frequencies.
3. This a-c test method is used by most power systems on most types of insulation.
4. There is little difference in test methods because of variation of voltage ratings of apparatus under test.
5. D-c insulation resistance tests are used by most power systems in evaluating cable and rotating machinery insulation.
6. Voltage withstand tests, both alternating and direct current, appear to be used primarily for acceptance tests on apparatus. Considerable variation in practice as to test voltages and times of application is found.
7. Alternating voltage distribution tests are limited to line insulators and bushings.
8. Corona detection tests, either alternating or direct current, are used on very few systems.
9. Dielectric absorption tests are mainly limited to cable, rotating machinery, and transformer insulation.
10. Very few field test methods were reported other than those listed in Questions 2 and 3.

CONCLUSION

THE MEMBERS of the subcommittee wish to express their appreciation for the generous response to the questionnaire. Space limitations made it impossible to include all of the information in the replies and made it necessary to omit from the tabulations any test method not used by more than one company. Nevertheless, it is felt that these data will be valuable in the future activities of the subcommittee and their inclusion in the replies is appreciated, even though they are not being published in this report.

REFERENCE

1. McGraw Central Station Directory. McGraw-Hill Book Company, New York, N. Y.

Standard on Thicknesses of Uncoated Thin Flat Metals Revised

A 1952 revision of the American Standard, Preferred Thicknesses for Uncoated Thin Flat Metals (under 0.250 inch), *B32.1-1952*, has been approved by the American Standards Association (ASA). It has been developed by ASA Committee *B32*, on Wire Diameters and Metal Thicknesses, jointly sponsored by The American Society of Mechanical Engineers and the Society of Automotive Engineers.

Twenty-five years ago, American industry in a general conference held by the ASA decided that it would be preferable to designate the diameters of wires, the thicknesses of metal sheets and plates, and the wall thicknesses of tubes, by decimal fractions of an inch, rather than by the traditional gauge numbers. A large number of gauge number systems was found to be in existence and the fact that a given number would designate different thicknesses, depending on the kind of metal, caused considerable confusion.

The ASA Committee *B32* not only adopted in principle designation by decimal inches, but also developed the American Standard *B32.1* covering the range of sheet metal thicknesses from 0.004 to 0.224 inch by values progressing in accordance with the 20-series of Preferred Numbers. The step-up between two consecutive thicknesses was 6 per cent.

The new American Standard differs from the 1941 edition in that the thicknesses are stepped up, from 0.004 to 0.236 inch, in accordance with the 40-series of Preferred Numbers, or by 3 per cent. Therefore, the designer has a wider choice of thicknesses. Also, some of the values that have been added in the new Standard are identical with, or close to, thicknesses contained in the gauge number systems. Thus it will be easier for sheet metal designers who so far have used gauge numbers to change to the 1952 American Standard, than it was for them to adopt the 1941 edition.

A basic advantage of the American Standard is that the recommended thicknesses apply to all sheets, independent of the kind of metal. This is important particularly where products, such as sheet metal covers, first made of one kind of metal have to be made of another metal, for example, due to priority regulations. The difficulties of substitution are minimized because the new products are dimensionally interchangeable with the original ones.

It is expected that the advantages of the new American Standard will cause it to be adopted more quickly in practice than has been the case with the 1941 edition. The main difficulty so far has been that warehouses have continued to stock sheet metal in accordance with gauge numbers.

A Ten-Stage Cold-Cathode Stepping Tube

D. S. PECK
ASSOCIATE MEMBER AIEE

Developments in the art of transferring a gas discharge from one point to another in a multi-electrode tube have led to the design of a 10-stage counting tube operating up to about 2,000 pulses per second. Such a tube can be used for pulse counting, frequency division, time measurements, and similar functions.

IN 1950, the development was reported of a type of cold-cathode gas-discharge tube in which the discharge is transferred or stepped from one position to another in response to input pulses. Recently such a tube, the *6167*, has been designed for production, having the features to perform a pulse-counting function with a minimum of circuit components and with a high degree of reliability. In one application, for instance, two of these tubes replace five double triodes and 22 neon lamps, with a corresponding reduction of other circuit elements.

Although the mechanism of discharge transfer used in this design was described[1] by M. A. Townsend of the Bell Telephone Laboratories, a brief review will serve to clarify description and discussion of the tube characteristics.

THE STEPPING MECHANISM

FIGURE 1 is a representation of a series of cathodes in which a gas discharge is shown to be present between cathode *K1* and the common anode. As long as the discharge current is within the capabilities of this cathode, and the adjacent cathodes, *B1* and *B2*, are at the same voltage as *K1*, or are positive with respect to *K1*, there is no tendency for the discharge to be transferred to either of these cathodes. Their breakdown voltages to the anode are reduced, however, because of their proximity to the ionization, and if their voltage is made sufficiently negative with respect to that of *K1* (as at point *C* on the input pulse shown at the left), breakdown will occur from the anode to one of these cathodes. Since *K1* is then positive with respect to the voltage of the new discharge, ionization is extinguished in this gap and transfer is thereby effected. The *B* cathode is then negative with respect to the *K* cathodes and will retain the discharge until its voltage is changed again, this time in a positive direction as at point *D* on the input pulse. When it becomes sufficiently positive with respect to the *K*'s, the same sort of transfer will take place to a *K* cathode. If it can be assured that the discharge always transfers in a given direction, then it may be moved from *K1* to *B2* and to *K2* by means of a complete negative pulse on the *B*-cathode bus.

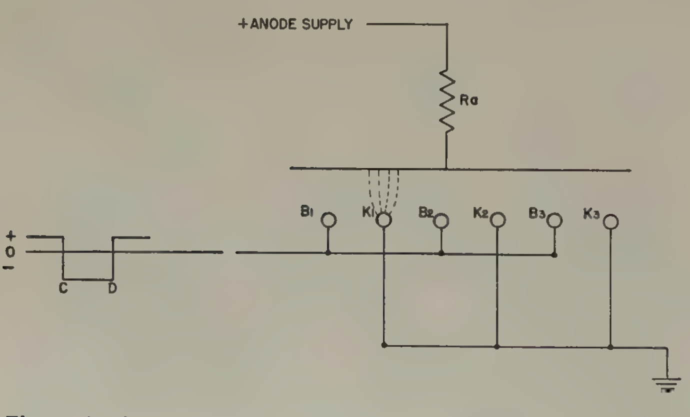

Figure 1. In a 3-stage stepping system, discharge is transferred between output cathodes by application of a negative input pulse

Some form of selective mechanism is necessary to make sure that the discharge always moves in the desired direction and this is done by making each cathode with a low-efficiency portion and a high-efficiency portion. The low-efficiency portion is in this case a length of molybdenum wire and serves to extend into the region of ionization of the preceding cathode to effect an easy transfer but maintains conduction so poorly that the discharge travels immediately to the high-efficiency portion which is here made up of a coil of molybdenum wire forming a "hollow." This hollow is much closer to the next forward cathode than to the preceding cathode, thereby causing much greater reduction of breakdown voltage of the forward cathode than of the preceding cathode. This results in a preference for forward transfer.

THE 6167 TUBE

THE CATHODES used in this tube are shown in Figure 2. The two center cathodes are those used for practically all stepping and output cathodes. The pickup or low-efficiency portion is integral with the coil. On the right-hand side is the normal or "zero" cathode which has no pickup extension because it does not receive transfer by the usual forward-transfer mechanism. The cathode shown at the left has two pickup extensions because of its need for obtaining transfer from two directions as described later.

The assembly of these cathodes is shown in Figure 3. Here is seen the ceramic supporting body into which all the parts are glazed with a powdered glass mixture. A central disk anode is surrounded by 20 cathodes, each with its pickup extension located above the body of the

Full text of conference paper presented at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952.
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Figure 2. The extensions of the wire of the directional stepping cathodes (coils about 1/16 inch long) provide a discharge pickup portion of low operating efficiency

Figure 3. Twenty cathodes surround the central disk anode in the ceramic support of the stepping tube

preceding cathode. These are arranged in a closed circle and since, as has been shown, two cathodes are required for each stepping stage, this structure provides 10-stage continuous stepping. In each stage, the stepping cathode is designated as a B cathode and the output cathode as K.

The tenth stage precedes the first stage in this configuration, but it would be undesirable to use the tenth output cathode as a "zero" or normalizing position because of interference with the functions of this electrode as an output cathode. A normal cathode is therefore added outside the counting ring and operating into the first counting stage. The discharge may be returned to this cathode from any point in the tube by a large negative pulse in order to initiate a new count. Its location in this assembly is shown under the hole near the anode edge at the front. The first transfer cathode B_1 is shown immediately in front of the normal cathode with the two pickup extensions which enable it to transfer either from K_{10} or from normal.

This type of glazed assembly imparts considerable strength to the structure. Mechanical tests on these tubes and its components show no resonant frequencies below 1,000 cycles. The tube will withstand occasional shocks in the order of 400 g of 2 milliseconds duration.

Figure 4 shows the *6167* tube. The upper part of the envelope is covered with a light deposit of sputtered material which does not, however, seriously reduce visibility of the cathode discharge. The tube has a bulb diameter of $1^1/_8$ inches and a maximum seated height of $1^{15}/_{16}$ inches. The filling gas is neon.

A bottom view of the tube is seen in Figure 5. This shows 16 stem leads whereby connections are made to each of the output cathodes, the transfer cathodes, normal cathode, anode, and an auxiliary anode. The accompanying socket has been procured to accommodate this stem. It may be pointed out that both stem and socket are potentially 20-terminal components.

OPERATING CHARACTERISTICS

The operating current range is from 1 to 3 milliamperes. Anode-to-cathode breakdown voltage is in the range of 180 to 300 volts and the discharge is sustained at about 110 volts. Breakdown of one cathode to the anode immediately reduces the anode potential to the sustaining value and prevents conduction at any other point, so that only a single discharge will occur in the tube. The tube has an external electrical connection to each output cathode to allow getting a signal from any stage, or to allow initia-

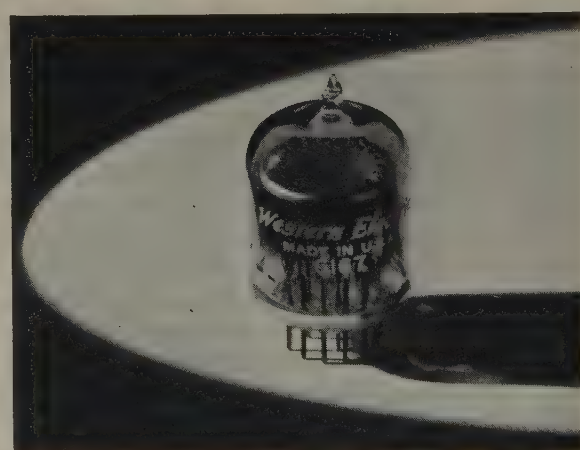


Figure 4. The gas discharge stepping tube which is approximately 2 inches high

Figure 5. The 16-prong base of the stepping tube and its socket

tion of the count on a selected cathode. In addition, the position of the discharge may be seen from the top of the tube so that a visual output signal is obtained. In fact, although this type of tube was visualized as being of miniature size, a larger bulb was found desirable in order to obtain a more suitable visual signal.

An obvious performance requirement of these tubes is

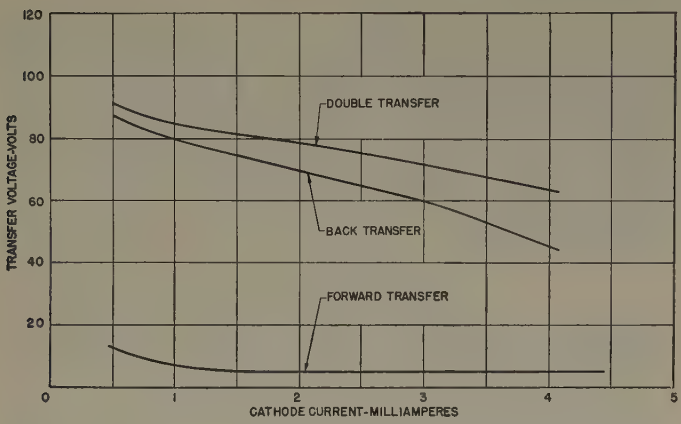


Figure 6. Typical transfer voltages as functions of operating current

that transfer always takes place in the forward direction. The degree of selectivity for proper transfer is shown in Figure 6 where it is seen that, over the rated operating range of 1 to 3 milliamperes, forward transfer normally will occur at less than 10 volts and back transfer (to the preceding cathode rather than to the forward cathode) at 60 to 80 volts.

The value of back transfer is important basically in that its excess over forward transfer is the design margin against failure to step, since failure eventually may occur by an increase in forward transfer voltage. With any margin, however, when a stepping voltage is applied to both the forward and back cathode, proper stepping will occur even though the magnitude of the drive exceeds back transfer.

Double transfer voltage, shown as the top curve of Figure 6, is the negative voltage of an output cathode with respect to an adjacent operating output cathode, which will cause transfer directly to it, by-passing the intermediate stepping cathode. This is of interest when obtaining output signals from the K cathodes is considered.

Output signals may be developed across load resistors in series with each output cathode as shown in Figure 7. This raises the potential of the operating K cathode above that of the other K cathodes so that the double transfer voltage may be approached, the limiting safe value being 45 volts at the maximum current of 3 milliamperes. Under dynamic conditions, however, the preceding stepping cathode may not be deionized at the time output voltage is developed across the load, and the obtainable output signal may be reduced at the higher frequencies below that obtainable at low frequency. This becomes apparent above 1,000 cycles and marked above 2,000 cycles.

It may be seen that a slow rise of output voltage on K_2, for instance, may allow proper deionization of B_2 after transfer and thereby allow a greater output at a given frequency, or operation at higher frequency. This can be obtained by the use of capacitors in parallel with the load; this also results in delay in reduction of the K_2 output potential after forward transfer to B_3 and reduces the time during which B_3 must hold the discharge before attempting the transfer to K_3. That is, if K_2 is still positive with respect to K_3, proper transfer may take place regardless of residual ionization in K_2.

When output voltages are obtained, the drive amplitude must be sufficient to carry the B cathodes from a bias above the output voltage (as indicated in Figure 7) to a point below ground to insure put-out of the previous K, so that the drive must be greater than the output. At low frequency in a resistive circuit, the shape of the input drive signal is not critical. As limiting frequency is approached, the shape becomes important in that a square wave (for example), as contrasted to a sine wave, would tend to speed transfer from the pickup portion of a cathode into the hollow, thereby reducing the tendency for back transfer.

To prepare the tube for starting a new count, the discharge may be returned from any point in the tube to the normal cathode outside the counting ring by application of a large negative pulse. In order to effect transfer from the opposite side of the tube, this pulse should be as large as would be required to initiate conduction at the normal even with no other discharge present. Anode-to-normal cathode breakdown may be as high as 300 volts, and since operating cathode potential is about 110 volts below the anode, an additional negative signal of 190 volts below the operating cathode level would be required.

It may be desirable to operate the tube with no individual outputs but with an output signal coincident with

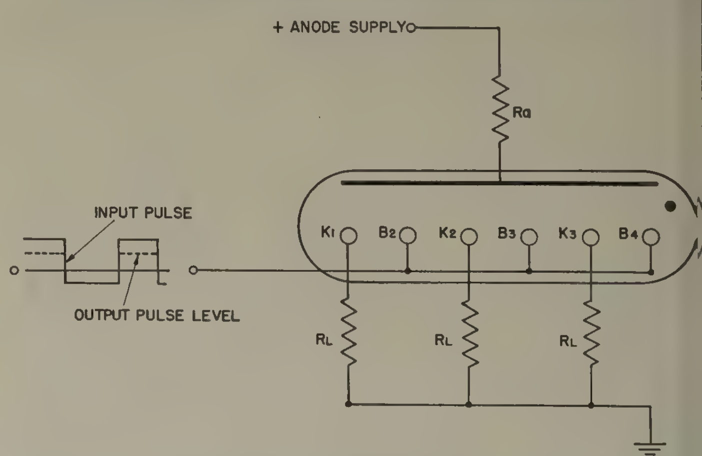


Figure 7. Schematic showing connections for individual output signals

each tenth count. This signal should be sufficient to drive the following tube in a decade chain or operate cold-cathode triodes or other electronic devices. An auxiliary anode is provided for this purpose, operating when discharge is present on K_{10} cathode.

Figure 3 shows the auxiliary anode assembly located directly underneath K_{10}. This consists of a molybdenum

wire extending through a ceramic sleeve glazed into the main ceramic body. The end of the wire is sufficiently exposed to K_{10} so that breakdown readily occurs when K_{10} operates, and the sleeve, which is grooved to prevent leakage due to sputtered material, protects the auxiliary anode so that a high breakdown voltage is required when discharge is present on other cathodes.

These characteristics are shown in Figure 8. A considerable range exists for an auxiliary-anode supply voltage which will operate to K_{10} but not to other cathodes, the most likely of which would be adjacent B_{10} and B_1. When the auxiliary anode conducts, the difference between its supply bias and voltage drop to K_{10} (about 112 volts) will appear as a negative output signal, which then may be in the order of 100 to 150 volts. Figure 9 presents a typical auxiliary-anode circuit. The auxiliary discharge may be put out as the main discharge is transferred out of K_{10}, or the circuit may operate as a relaxation oscillator if the main discharge is not allowed to rest on K_{10}. Refinements of this circuit would depend on the main discharge magnitude and waveshape, input and bias conditions, frequency, and similar considerations.

These tubes are now being applied under conditions of 1,000 drive pulses per second, or 2,000 cathode-cathode transfers per second, without output signal from the cathodes, but with operation of the auxiliary anode. Under these general conditions, limiting frequency varies from 2,000 to 2,500 pulses per second. Under resistor-capacitor load conditions and without use of the auxiliary anode, a typical tube has been operated at as high frequency as 12,000 pulses per second. Requiring output from the auxiliary anode, however, limits operating frequency because of the time required for auxiliary-anode breakdown after initiation of conduction on the K_{10} cathode. This time may be in the order of 130 microseconds at 3 milliamperes cathode current and 250 volts on the auxiliary anode.

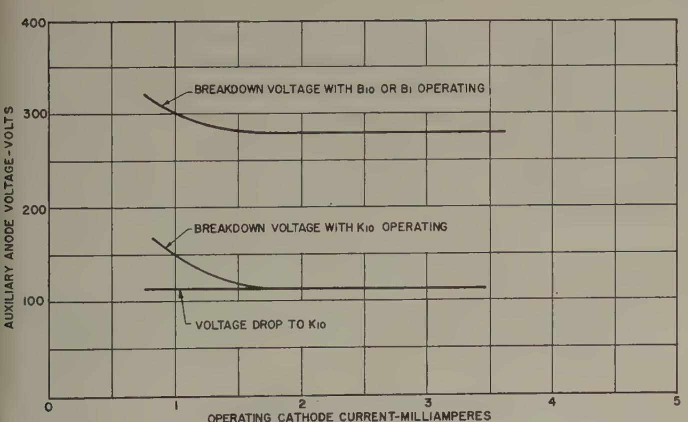


Figure 8. Typical auxiliary anode characteristics

LIFE

Life of tubes with such pure metal cathodes may be affected by sputtering of the cathode material or gas clean-up, neither of which appears to be a factor in this tube. Life may be affected also by movement of contaminating materials within the tube. With regard to this factor, it is considered that the most severe operating condition is that of conduction from a single cathode for a considerable period of time. If contamination is present in the tube, this operation will encourage collection of contaminating material on the nonoperating cathodes and result in an increase in forward transfer voltage. All of these tubes are operated in this manner for a period of 48 hours at a current beyond the maximum rating; satisfactory tubes show a maximum increase in transfer voltage in the order of 1 volt over this period. The rate of change is decreased after the initial period, however, and a few tubes operating for longer periods on a single cathode indicate an over-all expected change of only a few volts in 1,000 hours. In general, this change completely disappears with subsequent operation for a few minutes on all cathodes.

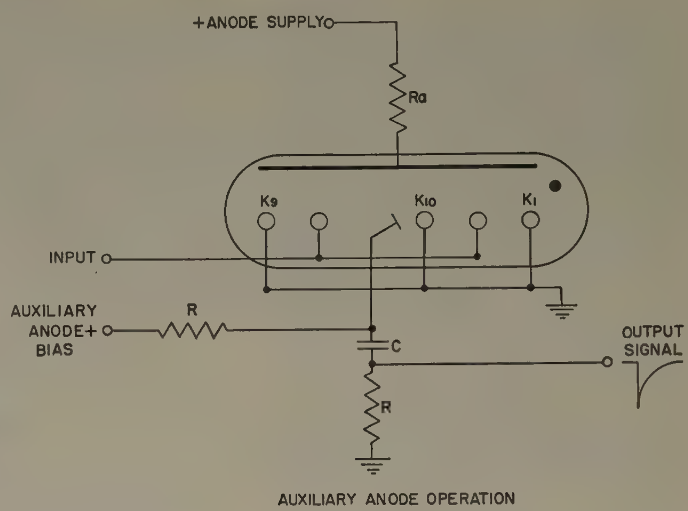


Figure 9. Schematic showing connections for auxiliary anode output

Essentially no changes are indicated in other characteristics. Similar operation within the operating current range would show much less change, and such tubes will undergo essentially no change for months of continuous operation when stepping on all cathodes. Intermittent operation will extend considerably the useful life of the tube in its socket.

CONCLUSIONS

This tube, then, would appear to be a circuit component of considerable stability, requiring no heater power, providing a simple means of obtaining both visual and electrical registration of input signals, and being capable of operating in decade chains or driving other electronic devices for purposes of pulse counting, frequency division, timing, pulse generation, or performing many similar operations.

REFERENCE

1. Construction of Cold-Cathode Counting or Stepping Tubes, **M. A. Townsend.** *Electrical Engineering*, volume 69, September 1950, pages 810–13.

INSTITUTE ACTIVITIES

Number of Technical Sessions Increased to 83 for 1953 Winter General Meeting

Since the 1953 Winter General Meeting was first announced (*EE, Nov '52, pp 1036–7*), the number of technical sessions and conferences being organized for the week of January 19–23 has been increased to 83. As only eight sessions can be accommodated at any time in the Statler, the headquarters hotel, the remaining sessions will be scheduled at the Engineering Societies Building, 33 West 39th Street. Among those subjects not previously mentioned are sessions on Petroleum Industry, Cathodic Protection, Storage Batteries, Ultraviolet and Infrared Sources and Applications, and Lighting Developments.

INSPECTION TRIPS

A program of inspection trips is being arranged which will include, tentatively, the following places of general and technical interest:

1. Radio City Music Hall
2. National Biscuit Company
3. United Nations—General Assembly Building
4. International Business Machines Company
5. New York City Board of Transportation—59th Street Power Plant
6. United States Naval Supply Depot
7. Brookhaven National Laboratory
8. Harbor Radar Installations
9. Du Mont Television Plant
10. Rambusch Decorating Company
11. Anheuser-Busch Brewery
12. Bell Telephone Laboratories

Details of these trips will be given in the January issue of *Electrical Engineering*.

SMOKER

The Smoker Committee, under the chairmanship of C. F. Bolles, announces that the smoker will be held at the Hotel Commodore on Tuesday evening, January 20. Reservations should be sent to the Smoker Committee at AIEE Headquarters. Tables for ten persons will be available and the price of tickets, including gratuities, will be $10.00 per person. Checks should be made payable to "Special Account, Secretary, AIEE." Reservations received after January 6 will not be honored.

DINNER-DANCE

The dinner-dance will be held Thursday night, January 22, in the Ballroom of the Hotel Statler. Tables for ten may be reserved in advance for parties large enough to fill them, and the Dinner-Dance Committee will arrange to combine smaller groups and individuals before the party begins. Members reserving tickets are urged to let the committee know if they wish to be seated with others who are making separate reservations.

The cost of the tickets includes tips and is $12.00 per person. Dress will be formal. Write or call Dinner-Dance Committee at AIEE Headquarters. Make checks payable to "Special Account, Secretary, AIEE."

LADIES' ENTERTAINMENT

The Ladies' Entertainment Committee, under the chairmanship of Mrs. E. S. Banghart, is planning a social program which should prove very enjoyable to the visiting ladies. The "Get-Acquainted Tea," which has become very popular, will be held on Monday afternoon. This function serves as an ideal means for the ladies to become acquainted at the outset of the 5-day meeting. Tuesday evening there will be a cocktail hour, followed by dinner and entertainment. Wednesday morning, a sight-seeing trip is being arranged, including a tour of the United Nations; on Thursday there will be a luncheon and fashion show. The custom of serving coffee each morning at Ladies Headquarters at the Statler will be followed again this year.

THEATER TICKETS

As in the past, tickets to the following shows currently playing in New York will be available to all out-of-town AIEE members during the week of the meeting.

	Wednesday Matinee	Evenings
An Evening with Beatrice Lillie (comedy-satire) with Reginald Gardiner	$5.40	$7.20
Bernardine Mary Chase's new comedy	4.80	6.00
Dial M for Murder (drama) with Maurice Evans	4.80	6.00
Guys and Dolls (musical)	4.80	7.80
Mrs. McThing (comedy) with Helen Hayes	4.80	6.00
My Darlin' Aida (musical) with Dorothy Sarnoff, Elaine Malbin	5.40	7.80
New Faces of 1952 (musical)	4.80	7.20
Pal Joey (musical)	4.80	7.80
South Pacific (musical)	4.80	7.20
The Fourposter (comedy) with Betty Field and Burgess Meredith	4.80	6.00
The Gambler (drama) with Alfred Drake	4.80	6.00
The King and I (musical)	5.40	8.40
The Male Animal (comedy) with Elliott Nugent, Martha Scott, Robert Preston	4.80	6.00
The Moon Is Blue (comedy) with Donald Cook, Barry Nelson, Janet Riley	4.80*	6.00
The Time of the Cuckoo (comedy) with Shirley Booth	4.80	8.20
Wish You Were Here (musical)	5.40	8.40
Cinerama (new movie technique)	3.60	4.00

* Thursday matinee.

All prices shown are brokers' prices for orchestra seats which are always $1.20 above box office prices. Whenever possible, tickets will be obtained at box office prices. The earlier requests will obviously have the best chance of avoiding the brokers' fees on the tickets.

Checks should be made payable to: "Theater Ticket Committee, AIEE." Requests also should include first and second choice of both name and date of show, and should be sent to: Theater Ticket Committee, AIEE, c/o Westinghouse Electric Corporation, Room 2502, 40 Wall Street, New York 5, N. Y.

Preference will be given in order of receipt to requests for seats in blocks of pairs and the committee reserves the right to reduce requests to sell-out shows to two tickets.

All ticket requests will be acknowledged promptly and, at the same time, refund will be made of any money due in excess of the price of tickets purchased.

Please do not include with theater ticket applications payment for any meeting fee or other item for which remittance should be made directly to Institute headquarters.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent prior to January 9, directly to the hotel of choice, and to only one hotel. AIEE should be mentioned in the request and a copy sent to W. G. Vieth, Chairman, Hotel Accommodations Committee, Western Union Telegraph Company, 60 Hudson Street, New York 13, N. Y. A second and third choice should be noted on this copy.

Due to the current accommodations situation in New York hotels, reservations for arrival on Sunday, January 18, are suggested. If the accommodations at the hotel requested are not available, the Hotel Accommodations Committee will transfer the request to one of the other hotels on the list.

Hotel rooms have been reserved at all

Future AIEE Meetings

Joint AIEE-IRE-ACM Conference on Electronic Computers
Park Sheraton Hotel, New York, N. Y.
December 10–12, 1952

AIEE-IRE-NBS Conference on High-Frequency Measurements
Statler Hotel, Washington, D. C.
January 14–16, 1953

Winter General Meeting
Statler Hotel, New York, N. Y.
January 19–23, 1953
(*Final date for submitting papers—closed*)

Southern District Meeting
Seelbach Hotel, Louisville, Ky.
April 22–24, 1953
(*Final date for submitting papers—January 22*)

North Eastern District Meeting
Sheraton Plaza Hotel, Boston, Mass.
April 29–May 1, 1953
(*Final date for submitting papers—January 29*)

the following conveniently located hotels:

Hotel Statler (meeting headquarters), 7th Avenue, 32d to 33d Streets

Single room with bath	$ 5.00 to $10.00
Double room, double bed	8.00 to 12.50
Double room, twin beds	9.00 to 17.00
Studio type	12.00 to 18.00
Parlor Suites	22.00 to 40.00

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	$ 5.50 to $ 7.00
Double room, double bed	8.00 to 9.50
Double room, twin beds	9.00 to 11.00

Hotel McAlpin, Broadway and 34th Street

Single room with bath	$ 5.00 to $ 9.00
Double room, double bed	8.00 to 13.00
Double room, twin beds	9.00 to 13.00

New Yorker Hotel, 34th Street and 8th Avenue

Single room, tub and shower	$ 5.50 to $ 8.00
Double room, double bed	8.50 to 12.50
Double room, twin beds	9.50 to 14.00

Hotel Martinique, Broadway and 32d Street

Single room with bath	$ 5.00 to $ 7.00
Double room, double bed	8.00 to 10.00
Double room, twin beds	8.50 to 11.00

Hotel Commodore, 42d Street at Lexington Avenue

Single room with bath	$ 6.00 to $10.00
Double room, double bed	10.00 to 12.50
Double room, twin beds	11.50 to 14.50

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	$ 7.50 to $10.50
Double room, double bed	13.00 to 16.00
Double room, twin beds	14.00 to 18.00

Rates are subject to 5 per cent New York City hotel room tax.

1953 WINTER GENERAL MEETING COMMITTEE

Members of the 1953 Winter General Meeting Committee are: C. T. Hatcher, Chairman; A. J. Cooper, Vice-Chairman; J. J. Anderson, Secretary; W. J. Barrett, Budget Co-ordinator; M. D. Hooven, Vice-President, District 3; L. F. Hickernell, Chairman, Committee on Technical Operations; G. T. Minasian, Publicity; J. A. Parrott, General Session; J. G. Derse, Dinner-Dance; D. E. Sullivan, Inspection Trips; C. F. Bolles, Smoker; J. G. Aldworth, Theater—Radio Television; W. G. Vieth, Hotel Accommodations; H. E. Martin, Registration and Checkup; Mrs. E. S. Banghart, Ladies' Entertainment; R. T. Weil, Monitors; J. B. Harris, Jr., Philadelphia Representative.

After explaining the work of the Engineering Manpower Commission, which has the support of AIEE, Mr. Quarles spoke about the participation of nonmembers in Institute affairs, and pointed out that special action of the Board of Directors is necessary if such men are appointed to technical subcommittees, as has been done in the past. He gave a background of what nonmembers have done and stated that the Institute should include them on committees because the fields they represent are fundamental to our own work.

Mr. Quarles then mentioned the crowded conditions in the Institute's headquarters and described how the AIEE has proposed that each of the societies occupying the premises go into their reserves to furnish some of the money to start a new building. He expressed the hope that a benefactor would be found who would provide financial assistance for this purpose. In closing, he thanked the chairman and other members of the general committee for their work in arranging the meeting.

The next speaker was H. J. Voorhies, vice-president and general manager, Standard Oil Company, Louisiana Division, whose topic was "Oil Progress in Louisiana." After showing how petroleum and natural gas are displacing coal as sources of energy and how oil is a more efficient fuel for locomotives than coal, Mr. Voorhies presented some data concerning Louisiana's position in crude oil production. That state ranked third in the country in 1951 with more than 200 million barrels per day, topped only by Texas and California, and in the matter of proved reserves per square mile it was second only to Texas with 47,000 barrels compared to Texas' 54,000.

Louisiana's oil fields are for the most part in the southern half of the state and their 668,000 barrels per day represent better than 10 per cent of the total oil produced in the United States. Approximately 35 per cent of the oil produced by one refinery is distributed by pipe line, 31 per cent by vessels, 30 per cent by barges, and 4 per cent by rail and truck.

TECHNICAL SESSIONS

Of the 26 sessions on the program, 13 were sponsored by the Power Division, six by the Industry Division, three by the Com-

New Orleans Section Is Host to 900 Attending Recent Fall General Meeting

The New Orleans Section demonstrated the South's famous hospitality when it was host to more than 900 AIEE members and guests at the AIEE Fall General Meeting held in the Jung Hotel, New Orleans, La., October 13–17, 1952. A total of 26 technical sessions and a general opening session were conducted during the 5 days including an all-day meeting of the Board of Directors; District 4 Executive Committee and several technical committees also held meetings.

Fifteen inspection trips were enjoyed by the members to New Orleans industrial plants. On the social side, a get-together party at International House was well attended and the stag smoker on Tuesday evening proved a great attraction as did the dinner-dance the following evening. On Thursday busses took members and their ladies to Biloxi, Miss., for a special sea-food dinner at the Buena Vista Hotel and swimming in the Gulf of Mexico. Special events were arranged for the ladies every day and the evenings found many members enjoying the Creole food found only in the Vieux Carré restaurants.

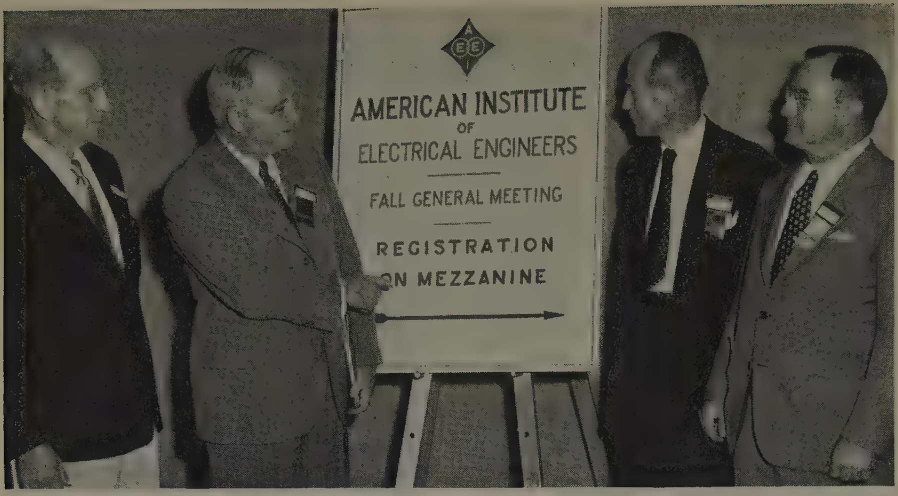
GENERAL SESSION

James M. Todd, chairman of the Fall General Meeting Committee, opened the general session held in the Tulane Room of the Jung Hotel with a brief word of welcome and expressed the hope that the visitors would become well acquainted with New Orleans. He introduced the governor of Louisiana, Robert F. Kennon, who after welcoming the guests stated that the progress of the state in the past decade is due "in a great measure to the know-how of the engineering fraternity." "Louisiana is fast getting into the business of being an industrial state," he said, "and we are serious about obtaining genuine and stable business here."

City Commissioner Victor Schiro had been delegated by the mayor of New Orleans to welcome the guests to the city. He told how their port is now the second in the country with two billion dollars of business annually. He presented the key to the city to AIEE President D. A. Quarles together with a certificate of honorary citizenship.

Mr. Todd introduced Mr. Quarles, who gave a résumé of the AIEE participation in the Centennial of Engineering in Chicago. He then reviewed the steps taken over the years to obtain unity among the professional societies, how the Engineers Joint Council came into being, and how it falls short in several respects of what is needed. Even though some progress has been made in exploratory moves and there is a keen interest in a common engineering association, there is still much to be done.

H. J. Voorhies, Standard Oil Company, (left) and Governor Robert F. Kennon of Louisiana with AIEE President Quarles (right) during the general session on Monday



The chairman and vice-chairmen of the General Committee for the recent Fall General Meeting confer in the lobby of the Jung Hotel. Left to right are C. P. Knost, Chairman J. M. Todd, B. E. Segall, and B. P. Babin

munications Division, three by general committees, and one by the Science and Electronics Division in which four papers on the subject of magnetic amplifiers were presented.

Many of the papers presented dealt with installations in the region where the meeting was held.

INSULATED CONDUCTORS

In two of the three sessions on insulated conductors, the uses of aluminum in cables, busses, open wire, and the related problems of splicing, connectors, corrosion, and equivalent conductance were presented and discussed by well-known engineers in the aluminum industry, operating companies, and cable manufacturers.

In the first session on insulated conductors, some of the papers were jointly sponsored with the Industry Division. Two papers dealt with the problem of grounding and corrosion protection of underground cable sheaths and oil- or gas-filled pipe lines and the grounding of coaxial and shielded cable. Another paper, written by F. S. Benson, deceased, of the Pacific Gas and Electric Company, treated the many advantages of the use of trays and troughs for supporting control and power cables in electric installations. In discussion of this paper, S. J. Rosch, Anaconda Wire and Cable Company, pointed out that the paper was a good one but a dangerous one, and he called attention to the need for taking into consideration the derating of cables in this type of installation and to the fact that even a conductor not carrying current should be taken into consideration in the derating because its volume chokes or blanks the heat dissipation. Victor Siegfried, American Steel and Wire, also discussed the paper and pointed out the accessibility advantage of troughs and trays. He noted, however, the danger of involvement in case of failures and the necessity for getting rid of sharp edges in the sheet metal work. The fourth paper in this session was presented by L. T. Frantz and it dealt with the many unique problems in connection with the operation of the electric system for the pumping of sewerage and water in New Orleans with many locations below sea level. The total connected load for pumping is over 60,000 horsepower.

FORUM ON PETROLEUM INDUSTRY

As the Institute has many members in the south and southwest who are concerned with electrical applications to the petroleum industry, and as a result of the decision of the Board of Directors that Institute activities should be increased in this field, a forum on the subject was held with the view toward exploring what might be done.

POWER

The session on power generation and protective devices on Monday afternoon started with two technical papers on surge phenomena in large unit-connected steam turbine-generators, which were followed by three papers on the use of industrial television in the power industry. E. R. Thomas, Consolidated Edison Company, read two of these papers; one by L. M. Exley, Long Island Lighting Company, on the direct viewing of furnaces with the aid of television, and the other by himself and W. L. Norvel, on the use of television in the monitoring of stack emission, in which the iris of the pickup camera was changed automatically to compensate for the varying brightness of the sky background. G. H. Wilson's paper, "Television in Industry," described the use of the Utiliscope, a system using the image dissector tube, not only in the power industry for the remote viewing of gauges, stacks, and so forth, but in steel mills where it is employed in different manufacturing processes.

SAFETY

Of the three papers comprising the session on safety, held on Wednesday morning, the technical paper, "Comparative Studies of New Push-Pull Methods for Pole-Top Resuscitation," by A. S. Gordon, Charles Frye, and M. S. Sadove of the University of Illinois College of Medicine, created the most discussion. Dr. Baker, who presented the paper, first outlined the Schafer method and then explained the newer arm-lift and hip-lift back-pressure methods for prone patients. He then showed how these newer means of resuscitation could be applied to the pole-top method and provided a series of respiratory graphs showing the cubic centimeters of air per respiration for each of the various methods, these being made under laboratory conditions. In the discussion which followed, E. W. Oesterreich showed slides of different conditions where the recommended pole-top methods had been impossible to use because of the relative positions of the victim, the rescuer, and the nearby wires. Certain improvisations had succeeded in all but one instance.

The conference papers presented were "Safety Regulations and How They Affect the Electrical Industry," by L. D. Price, National Electrical Manufacturers Association, and "The Role of the Supervisor in Safety Work," by W. H. Senyard, Louisiana Power and Light Company.

MANPOWER SHORTAGE IN POWER EDUCATION

Considerable interest was manifested in four papers presented at a session on education with J. D. Ryder presiding and a lively discussion ensued.

As an introduction to the subject, Professor Ryder presented an important paper based on a survey of 136 Engineers' Council for Professional Development accredited schools with returns from 102 schools, or 75 per cent. From the data, it was shown that 36 per cent of the graduates were in the power field and 64 per cent were in electronics. The anticipated number of graduates with the electrical engineering bachelor's degree in both power and electronics for the next 4 years was shown. In respect to scholarship based on records of two large midwestern universities, it was shown that a majority of the best students take the electronics option, and that in the year 1951–52, the utilities interviewed only 3.5 students per company visit as compared with 28 students interviewed by equipment manufacturers per visit and 19 students interviewed by the electronics and communication industries per visit.

The opportunities for engineers in the electrical utility industry were pointed out by R. F. Danner of the Oklahoma Gas and Electric Company. In the presentation, the author stressed the rapid growth of the utility industry, its magnitude, and the fact that it is a basic industry. This tends toward stability, and the size provides a diversity of interests with many opportunities leading to management or supervisory positions.

In an attempt to stimulate constructive thinking on the subject, a third paper which dealt with the shortage of power engineers in the utility industry analyzed the causes, the scope of utility engineering functions, past remedies, and new appeals. Regarding the latter point, the author, George S. Dinwoodie, president of the New Orleans Public Service Inc., suggested that more attention might be paid to the potentialities of pure research and that perhaps experimental research has not been sufficiently exploited.

The fourth paper entitled "The Equipment Manufacturer and Power Education" was presented by H. N. Muller, Jr., Assistant to Vice-President, Westinghouse Electric Corporation. The author explained that they could use those trained in the electronics option just as readily as those trained in the power option, and in respect to the diminishing numbers of those training in the power field, he stated: "I cannot name a major field of technical endeavor where the

long-range opportunities are greater." The author also stated that a detailed survey would reveal that the total number of administrative and policy level positions in the utility and electrical manufacturing companies of America exceeds that in all high-frequency fields today and will continue to do so in the foreseeable future. With respect to opportunities for young men in the power field, the author reviewed a number of noteworthy advances in equipment lines such as the trend toward larger and larger generating units; the possibility of tripling hydrogeneration in the next two decades; other sources of power such as solar collectors, wind power, heat pumps, and tidal energy; larger transformers; higher voltage transmission; higher interrupting capacities of circuit breakers, and so forth. Both Mr. Muller and Mr. Dinwoodie were in agreement with the thinking during the past few years that the schools should train the students thoroughly in the fundamentals and leave the specialized training and skills to be undertaken by the industries later.

SYSTEM ENGINEERING

Increased use of television, the advent of color television, air conditioning, possible use of heat pumps, and increase in the number of electric ranges and other electric home appliances in New Jersey is expected to result in about a 60-per-cent increase in the use of electricity for domestic purposes in the next 10 years.

This estimate was contained in a paper, "Forecasting the Demand for Electricity," presented by R. G. Hooke, Public Service Electric and Gas Company, Newark, N. J. His paper was given during a session on system engineering on Wednesday afternoon.

Mr. Hooke's report was based on data and calculations made in the Public Service territory which covers much of New Jersey. In 1951 the average kilowatt-hour consumption per customer was 1,386 and the load is expected to rise to 2,090 by 1961, he said.

The Public Service territory now has an 80-per-cent television saturation, with use of 220 kilowatt-hours annually per set. Mr. Hooke pointed out: "We expect some further saturation and we expect the change from black and white to color television further to increase consumption per set. We anticipate a further saturation of practically 100 per cent for television. The use of room coolers and fans will also increase the annual use per customer substantially. Assuming a 15-per-cent saturation of electric ranges, as compared with a present saturation of 3 per cent, this appliance can readily add 150 residential kilowatt-hours consumption per customer annually. Heat pumps and other space or local heating equipment constitute the biggest unknown."

Other papers presented were: "Load Forecasting—A Method Based on Economic Factors," by F. W. Brooks, Cleveland Electric Illuminating Company; "Load Forecasting and Utilization of Forecasts," by Carl Kist, Department of Water and Power, Los Angeles, Calif.; and "A Suggested Approach to Load Forecasting," by C. L. McNeese, Houston Lighting and Power Company.

RADIO COMMUNICATIONS

The session on radio communications, over which A. C. Dickieson, Bell Telephone Laboratories, presided, was held on Thursday afternoon and consisted of one technical and three conference papers.

Commander G. L. Ottinger, United States Coast Guard, explained the role radio and radar are playing in marine navigation, and Colonel W. M. Young described the radio activities of the Air Navigation Development Board. He enumerated several of the electronic devices designed for accelerating passage into and out of airports as well as for increasing the planes' safety in landing and taking off.

Howard Smith, Federal Telephone and Radio Corporation, presented an extemporaneous talk on pulse-time-modulated microwave applications in the pipe-line and utilities field.

"Radio Interference Control" was discussed by C. F. Maylott, Bendix Aviation Corporation. He explained the various sources of radio interference and the means being considered and taken to reduce these annoyances to a minimum.

CHEMICAL INDUSTRY IN THE SOUTH

The importance of engineering service by electrical manufacturers who supply equipment to the Southern chemical industry was stressed at a Thursday morning session.

While chemical plants are in the business of making chemicals, many of them have elaborate electric systems and all depend on electricity for their major operations; thus the electrical engineer plays a vital role in continued and successful processing.

W. C. Dreyer, Westinghouse Electric Corporation, in a paper, "Service Engineering Organization and Problems Peculiar to the Chemical Industry," pointed out the importance of the local service offered by engineers from the manufacturers. Chemical companies use a great diversity of large and complex electric equipment and it is desirable for electrical manufacturers to have available engineering service in the local area. He said "it is desirable" that the manufacturers have available in the local area consulting and application engineers to provide "engineering assistance to the customer in the solution of their application, design, operating, and maintenance problems" and to give a complete follow-through until installation of new equipment is completed.

The Field Service Engineers of the electrical manufacturer's district organization is one of the most important segments of the service available to the chemical industry; though their services are well known throughout the industry, they are all too infrequently publicized.

The following papers also were presented at this session: "Aspects of Delivering Constant Current to an Electrolytic Cell Line," E. H. Coxe, Ethyl Corporation; "Washing High-Voltage Equipment at the Ethyl Corporation," W. G. Whitley, Ethyl Corporation; "Lighting of a Southern Chemical Plant," J. H. Snow, The Dow Chemical Company; "Alcoa Point Comfort Power Installation," Howard Keefer, Aluminum Company of America.

PETROLEUM INDUSTRY IN THE SOUTH

In this session, with J. Z. Linsenmeyer presiding, three papers were presented. In the first paper, which was presented by R. S. Cannon of the Plantation Pipe Line Company, the highlights of 10 years of operations of the first large-scale completely electrified products pipe-line system were given.

In the second paper, which was entitled "Operation of Pipe-Line Pumping Stations by Remote Control," by M. A. Hyde, Jr. of the Westinghouse Electric Corporation,

Michigan Section Holds Dinner Meeting

More than 200 engineers heard E. V. Sayles, Consumers Power Company, discuss the British power supply system at the recent dinner meeting of the AIEE Michigan Section in Jackson. Shown at the speakers' table are, left to right: J. J. Carey, Vice-Chairman, Michigan Section; J. H. Campbell, Consumers Power Company; Mr. Sayles; A. P. Fugill, Chairman, Michigan Section; H. E. Crampton, Secretary-Treasurer

Lynn Section Executive Committee

Shown here are the officers and committee chairmen of the Lynn (Mass.) Section for 1952–53. Front row, left to right: Sigmund Stawicki, Assistant Secretary-Treasurer; A. M. Bjontegarde, Past Chairman; T. C. Sargent, Chairman; E. K. Rohr, Vice-Chairman; J. R. Macintyre, Secretary-Treasurer. Committee chairmen, back row, left to right: J. A. Melanson, Member-at-Large; R. A. Lowell, Basic Science; F. O. MacFee, Jr., Entertainment; W. E. Schwanhausser, Assistant Membership; W. H. Tucker, Membership; H. E. Crabtree, Electric Machinery; R. F. Buckley, Instruments and Measurements; W. R. Cox, Member-at-Large; D. M. Longenecker, Publicity; J. K. Sidebottom, Membership; F. E. Galopin, Illumination. Committee chairman not present include: J. S. Nelson, Transfers; T. O. Paine, Research; C. A. Woodman, Local Convention and Paper Competition; J. R. Cornell, Jr., Industrial Inspection Trips

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the author covered such points as provision to add very high frequency to provide voice communication with mobile units, flow measurement, the vibration relay or turbine relay which was designed specifically for the oil industry, and the supervisory control which would employ two channels to provide reliability. The presentation was made by C. R. Olson of the Westinghouse Electric Corporation. The third paper dealt with "The Electric System Reliability Required in Petroleum Refining Operations" and it was presented by E. R. Felton of the Esso Standard Oil Company. The author explained that the electric system required maximum reliability with a minimum of interruption time and he outlined the engineering design considerations for adequate transformer sizes, the undervoltage protection of motors, and the over-all co-ordination of all of the relays with the protective devices, which is most important.

At the conclusion of the session, E. U. Lassen, chairman of the Industry Division, suggested the possibility of organizing a special technical conference of 2 or 3 days duration on an important subject. As work which might be done he referred to the development of standards for electric equipment in the petroleum industry which would require co-operation between the user, the manufacturer, and the designer.

He also pointed out that the Committee on Chemical, Electrochemical, and Electrothermal Applications might not be the right place for a Subcommittee on Applications to Petroleum Work as the name of the committee implies that interest would be confined to refining only; hence a main committee might be organized to treat the electrical applications to petroleum work in refineries as well as in oil field operations. The suggested need for 880-volt motors in oil-field pumping operations was mentioned as a subject for consideration, and in conclusion Mr. Lassen stated that anyone interested in increasing AIEE activities in the applications to petroleum work should write to the chairman.

POWER TRANSMISSION

In the field of power transmission among the several papers presented were two very important contributions. A paper on "Insulation Co-ordination—Review and Suggested Revisions," by C. F. Wagner, E. Beck, R. L. Witzke, and W. L. Teague of the Westinghouse Electric Corporation, dealt with the lowering of BIL's (basic impulse insulation levels) below 1,050 kv. The opinions and methods of approach of one group of individuals working on this problem were presented in the hope that this analysis would assist in the understanding of the problem and promote the cause of national and international standardization of insulation levels. The second paper was entitled "Unbalance of Untransposed Overhead Lines" by E. T. B. Gross, Ray Berman, and C. T. Wint of the Illinois Institute of Technology. In this paper, in the case of electrostatic unbalance only, the authors have worked out sets of parameters for several different configurations of transmission lines which lead to the conclusion that for 230-kv transmission transpositions are unnecessary for distances under 250 miles. A fair figure for electrostatic unbalance was considered to be 3–5 per cent. From the methods outlined in the paper, others may readily work out conditions for different configurations. The authors are working on the case of electromagnetic unbalance.

WIRE COMMUNICATIONS SYSTEMS

In a session on this subject, four papers were presented with P. G. Edwards presiding. The first paper, entitled "Type *O* Carrier Telephone" by J. A. Coy and E. K. Van Tassel of the Bell Telephone Laboratories, Inc., was presented by J. A. Coy. The type *O* carrier is a family of four 4-channel systems providing 16 2-way talking channels on a single open-wire pair, and the system supplements rather than supersedes the older open-wire systems such as types *C*, *H*, and *J*. The system is particularly appropriate for the Louisiana territory and

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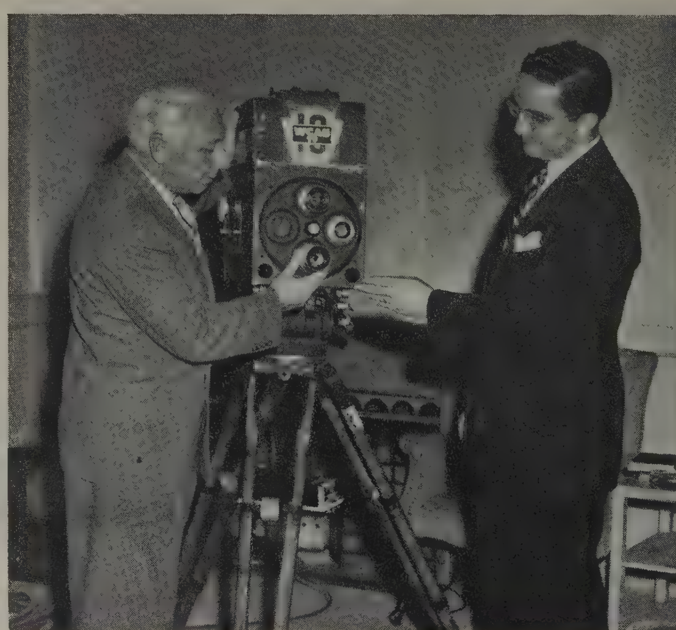
Philadelphia Section Tours TV Station



J. G. Leitch, left, vice-president in charge of engineering for the WCAU Stations, Philadelphia, Pa., explains the mechanism of a television camera to N. J. Christou, a member of the AIEE Related Activities Committee, during a recent tour of the new WCAU Radio-Television Center by some 300 members of the AIEE Philadelphia Section. The engineers also witnessed a behind-the-scenes showing of a regularly scheduled television program accompanied by technical explanations of the various production techniques used in the show

it has been made economical for short-haul use without sacrificing high standards of circuit reliability and quality.

The second paper, by Messrs. Rentrop and Hochgraf of the Bell Telephone Laboratories, Inc., dealt with the transposition designs for the type *O* carrier systems. The third paper, by J. Dechovitz of the Southern Bell Telephone and Telegraph Company, treated the applications of this type of carrier system.

The fourth paper in this session, by R. S. Caruthers of Lenkurt Company, Inc., was entitled "The 45*A* Carrier System."

COMMITTEES

Members of the Fall General Meeting Committee were as follows:

J. M. Todd, *Chairman;* C. P. Knost, B. P. Babin, B. E. Segall, *Vice-Chairmen;* E. I. Blanchard, *Secretary-Treasurer;* E. S. Lammers, Jr., *Vice-President, District 4;* H. E. Pritchard, Jr., J. R. Rombach, Jr., *Members-at-Large;* F. E. Johnson, H. C. Swan, J. C. Ryan, B. H. Bell, H. A. Schaeffer, Jr., W. D. Stroud, W. J. Drawe, M. J. Cade, W. S. Leake, L. T. Frantz, D. H. Vliet, Mrs. A. J. Fransen.

The chairmen and vice-chairmen of the working committees were as follows:

Entertainment, B. H. Bell, Chairman, H. L. Deloney, Vice-Chairman; *Finance,* W. D. Stroud, Chairman, F. G. Hollins, Vice-Chairman; *Hotel and Registration,* H. A. Schaeffer, Jr., Chairman; *Inspection Trips,* H. C. Swan, Chairman; *Printing,* M. J. Cade, Chairman, E. H. Arnold, Vice-Chairman; *Publicity,* J. C. Ryan, Chairman, M. J. Cade, Vice-Chairman; *Reception,* L. T. Frantz, Chairman, C. W. Ricker, Vice-Chairman; *Sports,* W. S. Leake, Chairman, A. L. Soule III, Vice-Chairman; *Students,* D. H. Vliet; *Technical Program,* F. E. Johnson, Jr., Chairman, C. W. Ricker, Vice-Chairman; *Transportation,* W. J. Drawe, Jr., Chairman, R. F. Legeai, Vice-Chairman; *Ladies Entertainment,* Mrs. A. J. Fransen, Chairman, Mrs. J. R. Rombach, Jr., Vice-Chairman.

Air Transportation Sessions Highlight of Middle Eastern District Meeting in Toledo

The AIEE Middle Eastern District Meeting which was held at the Commodore Perry Hotel, Toledo, Ohio, October 28–30, 1952, was attended by 632 members from 20 states and Canada, France, and England. Sixteen technical sessions were conducted, of which five were devoted to electrical aspects of air transportation. A stag smoker was well attended on the first evening of the meeting and the talk by Grove Patterson, editor-in-chief of the *Toledo Blade,* made the Wednesday evening banquet a memorable occasion. Four inspection trips were enjoyed by the members.

Charles E. Ide, president of the Toledo Edison Company, was the honorary chairman of the general meeting. After welcoming the guests to Toledo, Mr. Ide told about the newly formed power company which is to supply the electrical needs of the new Ohio plant of the Atomic Energy Commission. He then introduced W. L. Cisler, president of the Detroit Edison Company, who addressed the meeting over a closed-wire television circuit from Detroit on "Management Looks Ahead in the Electric Power Industry" (see pages 1079–82). This was the first time that an AIEE meeting has been addressed from a remote point by a televised speaker, whose image was reproduced in the ballroom of the hotel on several television receivers.

M. W. Keck, chairman of the meeting committee, after expressing his thanks to the local telephone company and Station *WSPD* for their aid in arranging the telecast from Detroit, introduced J. C. Strasbourger, vice-president of AIEE District 2, who told how the District Prize Paper Award Committee had 105 papers from which to choose the winning pair. Mr. Strasbourger made the following awards: First prize, $75, to R. A. Baudry, P. R. Heller, and H. K. Reamy, Jr., for their paper, "Improved Cooling of Turbine-Generator Windings"; and second prize of $50 to W. M. Leeds and D. J. Povejsil for their paper, "Out-of-Phase Switching Voltages and Their Effect on High-Voltage Circuit Breaker Performance."

At the luncheon which followed the general session, and at which M. W. Keck presided, the mayor of Toledo, L. E. Roulet, was introduced and welcomed the guests to the city. He was followed by J. C. Strasbourger who presented certificates of merit for services rendered over many years to the Toledo Section to J. A. Dinwiddie and W. M. Campbell.

On Wednesday evening the banquet was held in the Crystal Room of the hotel at which C. E. Ide was the toastmaster. After an excellent dinner he introduced Grove Patterson, editor-in-chief of the *Toledo Blade,* who presented "The Story of American Politics," a most interesting commentary on small and often extraordinary happenings which influenced selection of presidential candidates or secured their election to office.

TECHNICAL SESSIONS

Many of the technical papers which were presented at the sessions devoted to electric equipment and its problems in aircraft were excellently conceived and presented. One paper which evoked a great deal of discussion was a description of a new hydraulic constant-speed drive presented by E. E. Lewis and R. E. Thorn of the General Electric Company. With the increase in use of a constant-frequency a-c power supply in many aircraft electric systems, the need for a reliable source of constant-speed power to drive the a-c generator becomes greater. The constant-speed drive described by the authors is a controlled differential transmission, a unit in which only part of the total power is transmitted hydraulically. The transmission has an infinitely variable ratio between two limits but becomes a fixed ratio transmission outside of these limits.

Although the standard d-c bus voltage is 28 volts, some equipment on aircraft requires a higher voltage, most electronic apparatus falling into this category. These greater voltages are usually derived from small motor-generator sets or from the transformed a-c output of the ship's inverter or a-c system. How a problem was handled wherein 65 volts was needed with an 120-ampere power output was described by J. A. Hastings and E. L. Foster, Lockheed Aircraft Corporation, in their paper, "System of Boosting Direct Voltages for Special Aircraft Applications." Normally, the two 24-volt batteries are connected in parallel with each other and in parallel with the main 28-volt d-c generator bus. To supply the 65 volts needed for a searchlight, these batteries were connected in series with each other and in series with the bus. Due to line drop and battery voltage drop, the arc voltage was about 68 volts.

With the increased complexity of electronic

On the speakers' platform at the general session of the Middle Eastern District meeting are (left to right): M. W. Keck, chairman of the meeting committee; H. H. Henline, Secretary AIEE; J. C. Strasbourger, Vice-President AIEE District 2; C. E. Ide, honorary chairman who presided at the session; and Rev. C. G. Zehner, St. Paul's Evangelical Lutheran Church, who gave the invocation

W. L. Cisler, president, Detroit Edison Company, addressed the general session of the Middle Eastern District Meeting at Toledo over a closed-wire television circuit from the studio of station WWJ-TV in Detroit. Mr. Cisler's televised image can be seen on one of the receiver's screens

and electric equipment in aircraft during the last decade, the number of maintenance personnel in air lines has had to be increased almost tenfold. It also has been found economically sound to provide a system of preventive maintenance in order that the flying time of an airplane be kept at its feasible maximum. This and a plea to manufacturers to keep their products as simple as possible and easy to troubleshoot was made by A. J. Mustard of Eastern Air Lines, Inc., in his paper, "Maintenance of Electric Equipment in Modern Aircraft."

In their paper, "Consideration of Off-On-Modulated Reversing Clutch Servo Systems," T. R. Stuelpnagel and J. P. Dallas explained that this type of servo unit is adaptable to large aircraft servo control applications now using hydraulic or electrohydraulic servomechanisms. This unit would offer the advantages of all-electric control while avoiding the critical motor starting problem, associated line disturbance, and altitude brush problems of a servo-motor control.

H. H. Britten and D. L. Plette, General Electric Company, in their paper, "Development of a Static Regulator for Aircraft A-C Generators," describe a voltage regulating system consisting of a static-voltage regulator, rotating d-c exciter, and a-c generator. A comparison circuit accomplishes the voltage sensing and contains a glow tube, dry-disk rectifiers, and resistors. The output of this circuit is a voltage that is proportional to the difference between the generator voltage and regulator set voltage and is called the error signal. This can control the excitation of the a-c generator and cause its output voltage to remain relatively constant regardless of load, speed, and power factor. Two stages of magnetic amplification are used to increase the power level of the error signal.

In "Economic Factors for Aircraft Electric Power Systems" by H. J. Finison, R. M. Bergslien, and L. J. Stratton, all of the Armour Research Foundation of Illinois Institute of Technology, it is shown that the weight of the equipment is an important economic factor which is capable of quantitative evaluation.

F. B. McCarty and G. W. Hills, Consolidated Vultee Aircraft Corporation, presented "Automatic Synchronizing for Aircraft Alternators." The authors discuss an automatic synchronizing system in which the alternator is brought into phase with the bus frequency and held at this point until the circuit breaker is closed manually. This system was considered superior to others considered in that it had fail-safe characteristics, a simplicity of design, and light weight.

Twenty-six papers in all were given on the electrical phases of aircraft transportation and from the amount of enthusiastic discussion which resulted in many instances, a great deal was gained by the large audiences which crowded each of the five sessions.

J. C. Strasbourger, Vice-President AIEE District 2, at right, presented the Toledo Section's Award of Honor to J. A. Dinwiddie, Westinghouse Electric Corporation, past chairman of the Toledo Section, left, and W. M. Campbell, Bull Dog Electric Products Company

ELECTRICAL APPLICATIONS IN THE GLASS INDUSTRY

Three District papers and one technical paper were presented in this session over which J. E. Arberry, Pittsburgh Plate Glass Company, presided.

In the first paper, C. R. Olson, Westinghouse Electric Corporation, discussed the relative merits of induction regulators and saturable reactors for the electric melting of glass. The change in the resistivity of glass with temperature is very rapid; for example, for one particular soda-lime glass the resistance varies inversely as the eighth power of the temperature. Thus if a constant current is maintained to electrodes of a furnace, the system tends to become self-regulating since an increase in temperature is accompanied by a decrease in resistance and so a decrease in heat input, and conversely. Now more power is required to raise the temperature of the glass than to hold it, therefore, the power supply should be capable of supplying a high voltage with low current under low-temperature starting conditions and as the operating temperature is raised, a low voltage with a relatively high current is needed. To meet these conditions the ideal power supply should give a constant power input to heat the glass and be capable of reducing the power when the desired temperature is reached. The saturable-reactor and the induction-regulator systems were compared and found to be about the same in their operating efficiency.

N. A. Dragics, Owens-Corning Fiberglas Corporation, described the manufacturing process of his company's product and the necessary variations in it which are made by varying the speed of the drive motors in the production line. As these motor speeds are interdependent and must be held closely to various ratings, the speed regulators are of primary interest. Tachometer generators connected to various sections were used as the speed signal and referred to the speed of the master section, the oven. The regulator was installed with its armature in series with the armature of the drive motor and the excitation to the regulator was provided by tachometer generators. It was found that the speed relationship could be maintained within ±0.5 per cent of rated speed. Although this scheme was successful, it was felt that a separate generator for each drive motor would be better even though the drive was not to be regulated.

In his paper, "Electric Power Applications in the Glass Industry," E. A. E. Rich, General Electric Company, described the various ways which electric power was

employed in the manufacture of glass and different glass products.

The final paper, "Electric Glass Welding," was presented by M. R. Shaw, Corning Glass Works. He described welding processes for handling all kinds of joints in both straight and curved bodies. It is possible to develop higher temperatures than with flames alone and a faster heating rate is possible without danger of destroying the surface of the material. The highly localized nature of the heat from this process eliminates the possibility of distortion in the glass and since accurate control of the heat is possible, assures better quality.

COMMITTEE

The chairmen of the committees for the Middle Eastern District Meeting are as follows: M. W. Keck, Chairman, General Meeting Committee; Roy Stott, Secretary-Treasurer; L. H. Fox, Chairman, Toledo Section; L. E. Smith, Scheduling; J. W. Cofer, Technical Program; W. H. Schwalbert, Special Meetings and Inspection Trips; D. L. Rexford, Registration and Finance; W. E. Boruh, Entertainment and Publicity.

University of Toledo Is Host School for District 2 Student-Counselor Meeting

The University of Toledo engineering faculty and students were hosts to more than 300 representatives of 27 colleges and universities at the AIEE District 2 Student-Counselor Meeting held October 31 and November 1, 1952. A conference of the student chairmen took place on Friday morning and at the same time the Counselors were in conference. At the conclusion of these conferences, a group photograph was taken, followed by a luncheon in the university cafeteria.

In the afternoon inspection trips were made to the following Toledo plants: Electric Autolite, Toledo Scales, and Haughton Elevators. A banquet was enjoyed in Nash Hall in the evening at which Professor D. D. Ewing, Purdue University, was the principal speaker. On Saturday morning, a joint Student-Counselor Meeting was held in the Student Union lounge.

Professor Tsute Yang, Counselor of the University of Toledo Branch, was chairman of the conference of Counselors. He introduced Professor W. F. Brown, who welcomed the group to the college and especially to his department of electrical engineering. Professor Yang then reported on the meeting of the Committee on Student Branches held at the Summer General Meeting in Minneapolis. Among other actions taken by the committee, the new allotment of $1.00 per year per Student member was explained; the method of payment being 50 per cent at the start of each semester for those students enrolled as Student members by November 1 and an accounting of the Branches' funds twice yearly, the same as the Sections.

J. C. Strasbourger related the history of the offer of the Radio Corporation of America to pay the traveling expenses and maintenance of Student prize-paper winners from Districts 1, 2, and 3 to visit the company's research laboratories at Princeton.

Professor F. C. Powell reported on the student meeting at Pennsylvania State College May 2–3, where prize papers were given. (See *EE, Aug '52, p 761.*) He went on to speak about the problem of getting students to prepare papers for competition and asked for suggestions from the group. Several of the Counselors told how it was done at their colleges, but the consensus was that it is only the exceptional student who will take on the extra work of preparing a paper properly. It was voted that papers in triplicate must be submitted for competition.

The question was raised, shall Student Branch meetings for prize-paper competition be held at the same time as District meetings of the Counselors? It was voted to hold these meetings separately and that the prize-paper competition be held as late as possible in the spring.

Professor E. R. Welsh's invitation that the next Counselor meeting be held at Howard University was accepted and Bucknell University was selected for the next prize-paper competition in the spring.

The final subject considered was program planning and how to get better attendance at student meetings. Several of the Counselors related the procedures followed at their colleges: at the University of Pittsburgh, a "course" is given consisting of student meetings, for which college credit is given; at Pennsylvania State College plans are being formed to get recent graduates to address meetings, which are to be held during the day instead of evenings. The subject was tabled.

Professor W. F. Brown was toastmaster at the Student Activities Committee banquet, which was the first one to be held in the new Nash Hall. After the invocation by the Reverend Charles Mooney, of Gesu Church, the president of the University of Toledo, A. S. Knowles, welcomed the guests. This was followed by a short talk from L. H. Fox, chairman of the Toledo Section.

AIEE Vice-President J. C. Strasbourger then introduced Professor D. D. Ewing, AIEE Director and head of the School of Electrical Engineering, Purdue University, whose subject was "Student Branches of the AIEE." After giving a thumbnail sketch of how the number of Student Branches of the Institute has grown from 15 in 1902 to 132 at the present time, the speaker dealt with the problems encountered by the Branch Counselors and Branch student membership. One of the problems is to see that properly qualified students are elected to lead the activity, men who are not overloaded with other college activities and who will attack the Branch work with enthusiasm. The Counselor, of course, must know the Institute's regulations concerning Student-Branch activities and be a guide and inspiration to the officers and membership of the Branch. (Professor Ewing's address is to be published in the January 1953 issue.

Student Branch Counselors gather following their recent conference at the University of Toledo. Front row, left to right: AIEE Vice-President J. C. Strasbourger; H. S. Bueche, University of Delaware; Tsute Yang, University of Toledo. Second row, left to right: A. P. Powell, Pennsylvania State College; G. C. B. Rowe, AIEE Headquarters; K. F. Sibila, University of Akron; F. C. Powell, Drexel Institute of Technology; R. W. Young, Catholic University of America; J. L. Fuller, District 2 Secretary. Third row, left to right: E. C. Dubbe, University of West Virginia; G. H. Royer, Carnegie Institute of Technology; R. W. Shindler, Fenn College; E. R. Welch, Howard University; K. A. Fegley, University of Pennsylvania; T. Larsen, Johns Hopkins University. Back row, left to right: C. F. Evert, University of Cincinnati; R. C. Gorham, University of Pittsburgh; Norman Ames, George Washington University; AIEE Director D. D. Ewing; D. G. Howard, United States Naval Academy

Headquarters Staff Member Retires After 40 Years Service With Institute

Miss Flora B. Hallock, secretary to AIEE Secretary H. H. Henline and a member of the Headquarters staff in New York, N. Y., for 40 years, retired October 17, 1952.

Miss Hallock was born in Ossining, N. Y., October 16, 1886, and joined the staff of AIEE Headquarters in 1912 as a stenographer in the Business Department. She became secretary to F. L. Hutchinson, then Secretary of the Institute, in 1917, and worked with him for 15 years. When Mr. Henline succeeded Mr. Hutchinson as AIEE Secretary, Miss Hallock became secretary to Mr. Henline.

Since 1917 Miss Hallock has had contact with everything going through Institute Headquarters. She was in charge of Section and Branch records and committee organizations in recent years. Her most responsible work was reporting on the Board of Directors meetings held in New York City.

During her long association with the AIEE, Miss Hallock always was interested in what was best for the Institute and took a great interest in Institute activities.

Miss Hallock is the second Headquarters staff member to retire for long service since the organization of the retirement system in 1943. She will reside in Florida.

More Than 6,000 Attend Recent National Electronics Conference

With "Electronics for Defense and Industry" as the theme, the eighth annual National Electronics Conference convened at the Hotel Sherman in Chicago, Ill., September 29 through October 1, 1952.

Total attendance at the 3-day conference was 6,165 as compared to last year's attendance of 4,033. The technical program of some 97 papers covering a broad field of electronic research, development, and practical application was supplemented by 120 booths of exhibits by manufacturers and institutions in the electronics field. The conference was sponsored by the AIEE, Institute of Radio Engineers (IRE), Illinois Institute of Technology, Northwestern University, and the University of Illinois, with Purdue University, the University of Wisconsin, and the Society of Motion Picture and Television Engineers participating.

At the first of three luncheon meetings, Dr. E. W. Engstrom, vice-president in charge of the RCA Laboratories Division, discussed the problems of the electronics industry "today, tomorrow, and the day after tomorrow." Major General George I. Back, Chief Signal Officer of the United States Army, spoke at the Tuesday luncheon meeting. In his address, "Communications and Electronics in the Army," he called upon the engineers attending the conference to help the Signal Corps close the gap—both in time and space—between the front-line soldier and the research scientist and engineer. At the Wednesday luncheon, Dr. Harner Selvidge, Director of Special Products Development for the Bendix Aviation Corporation, talking on "Scientific and Electronic Methodology," stated that too many electronic engineers are only high-grade technicians, ignorant of scientific mathematical methods.

Social highlight of the conference was the AIEE–IRE–National Electronics Conference banquet held on Tuesday evening. The conference also sponsored a 3-day social program for the ladies which included a tea, a tour of Marshall Field and Company, and various sight-seeing and shopping trips.

All technical papers presented will be published in volume 8 of the *Proceedings* of the National Electronics Conference, which will be available at a cost of $5.00 after January 15, 1953. Copies may be ordered from the National Electronics Conference, Inc., Karl Kramer, Executive Secretary, 852 East 83d Street, Chicago 19, Ill.

Officers of the 1952 conference were

Dr. J. A. M. Lyon, President; Kipling Adams, Chairman of the Board; J. D. Ryder, Executive Vice-President; Karl Kramer, Executive Secretary; R. R. Jenness, Secretary; Ralph Benedict, Treasurer; O. I. Thompson, Arrangements Committee Chairman; C. E. Barthel, Proceedings Committee Chairman; R. M. Krueger, Exhibits Committee Chairman; R. M. Soria, Program Committee Chairman; LeRoy Clardy, Procedures Committee Chairman; S. R. Collis, Publicity Committee Chairman; A. J. Ward, Housing Committee Chairman

Villanova Student Branch Announces Plans for 1952–53

The Joint AIEE–Institute of Radio Engineers (IRE) Student Branch at Villanova College, Villanova, Pa., has announced plans for the year 1952–53. These include a series of monthly meetings with related field trips.

Topics for the meetings were selected as being comprehensive in the broad field of electrical engineering and include production, research, power, illumination, communication, maintenance, and control. The field trips are scheduled before the formal meetings so that the audience will have a knowledge of the general organization and type of work which the speaker will discuss.

The prize paper competition has been made compulsory for all senior students and is run in conjunction with a seminar in electrical engineering design. Also, the Branch newsletter will again be published.

Tentative plans and preliminary organization which are now being formulated include a formal meeting to which alumni will be invited, a combined meeting of all student technical societies at which a talk will be presented on "The Civic Responsibilities of the Engineer," and a banquet at the end of the school year in honor of the faculty of the electrical engineering school.

Student Branch officers and Counselors for the year are: C. A. Quinn, Chairman; J. V. Dougherty, Vice-Chairman; E. F. Corini, Treasurer; R. L. Brabson, Secretary (AIEE); J. T. Saganowich, Secretary (IRE); J. B. Clothier, Counselor (AIEE); J. A. Klekotka, Counselor (IRE).

Annual Report Issued by Engineering Societies Library

According to its recently issued Annual Report for the year October 1, 1951, to September 30, 1952, the Engineering Societies Library this year served more engineers by mail and telephone than in any previous year. Also, for the first time in its 39 years, the Library thus served more nonvisitors than visitors. Income from searching, translating, and photocopying increased and the Library's expenses have been kept within its income.

Much attention has been given to making the facilities and services of the Library better known and various promotional activities and exhibits are being planned. Income from photoprint, microfilm, search, and translation services has tripled in the past 20 years, while the Founder Societies support has increased about 50 per cent as a result of increased membership. In addition, certain other technical societies have contributed $1,900 to the Library while Nuclear Development Associates has donated $175. In addition to the technical translation work done for engineers, the Library staff translates letters for the Founder Societies at a very low charge.

The report also notes that during the year the Library staff prepared reviews of 484 books valued at $2,770. These reviews are supplied to the four Founder Societies, the Engineering Institute of Canada, and the Engineering Index. In addition to the value of books received for review, the Library spent $1,947 for books that were not reviewed.

A new Engineering Societies Monograph, "The Buckling Strength of Metal Structures," by Friedrich Bleich, was published. The royalties from this series, which is controlled by a separate committee of the Founder Societies, are paid to the Library. Royalties received by the Library since the series started in 1931 amount to $9,999.29.

The snow, ice, and permafrost bibliography being received from the Library of Congress in return for work given them, increased from 600 to 3,000 references.

Periodicals form a very important part of the Library's collection and are acquired through subscription, exchange, and gift. Other acquisitions include volumes, maps, searches, and pamphlets. Net accessions as of September 30, 1952, total 190,031: 171,181 volumes, 13,534 maps, and 5,316 searches. More than one-third of the items kept by the Library were gifts.

Schenectady Section Is Host to Machine Tool Conference

With the AIEE Schenectady Section as host, the fifth annual AIEE Conference on Machine Tools was held at the Hotel Ten Eyck, in Albany, N. Y., October 29–31, 1952. The conference was sponsored by the Machine Tool Subcommittee of the Institute, of which J. M. Delfs is chairman.

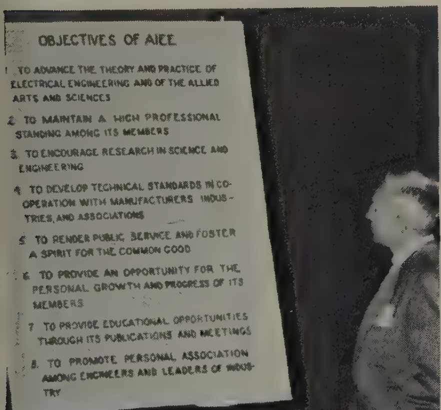
Featured at the meeting was an address by Tell Berna, general manager of the National Machine Tool Builders Association, who spoke at the banquet on Wednesday evening. Mr. Berna discussed "The Machine Tool Industry at the Crossroads." The speaker at the Thursday luncheon was H. A. Winne of the General Electric Company.

Some 11 technical papers were presented during the 2-day meeting. Chairmen for the various sessions were K. O. Tech, Cross Company, on Wednesday; E. J. Rivoira, Cincinnati Milling Machine Company, Thursday morning; and C. G. Hemlick, Westinghouse Electric Corporation, on Thursday afternoon.

Schenectady Section Opens 50th Year With Smoker

Ushering in their 50th year, the AIEE Schenectady Section entertained more than 500 members at a smoker on October 22, 1952, at the Edison Country Club in Rexford, N. Y.

As keynoter for the coming season, F. M. Roberts, General Electric Company, emphasized the part the AIEE plays in maintaining the "Bill of Rights" of engineering thinking. As an assembly point for engineers in all industries, Mr. Roberts stated that this enabled assemblage and exchange of creative ideas for the over-all good of the profession, and the nation. C. C. Herskind, vice-chairman of the Schenectady Section, then outlined the schedule of meetings for the coming year.



F. M. Roberts, General Electric Company, points out the "Objectives of the AIEE" in his address at the Schenectady Section smoker

Following the formal presentations, the smoker continued with a program of varied entertainment and then adjourned for refreshments.

Officers of the Schenectady Section for this year are: H. C. Anderson, Chairman; C. C. Herskind, Vice-Chairman; R. K. Fairley, Secretary; and L. F. Lewis, Treasurer. W. A. Hunter was chairman of the Smoker Committee.

North Texas Section Tours Magnolia Laboratories

The October 1952 meeting of the AIEE North Texas Section was held at the Magnolia Research Laboratories. This was one of the Section's regular monthly meetings.

The meeting included a tour of the Laboratories during which the visitors inspected the magnetic tape recorder used in seismograph testing and well logging. Other special equipment used in the same field also was shown.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Television and Aural Broadcasting Systems (*C. E. Dean, Chairman; L. M. Rodgers, Vice-Chairman; R. K. Hellman, Secretary*). The latest developments in ultrahigh-frequency television and in color television will be covered by papers at two sessions of the January Winter General Meeting, according to plans initiated at a meeting of the committee on September 12. At the ultrahigh-frequency session the opening paper will be presented by Edward W. Allen, Jr., Chief Engineer of the Federal Communications Commission, who will discuss the importance of the new frequency range and describe the allocation plan. Other speakers are scheduled to cover transmitters, antenna performance, receivers, and field-intensity measuring equipment.

At the color television session, a similar introductory paper is planned, to be followed by detailed papers on production of the color signal, synchronization, and the utilization of limited-band cable facilities for color operation. In addition, a paper is scheduled describing the broadcasting of the recent national party conventions at Chicago, Ill., over both television and aural chains. Both the equipment and procedures which were used at these events will be covered.

Committee on Special Communications Applications (*A. T. Lattauzeo, Chairman; W. A. Ready, Vice-Chairman; G. J. Crowdes, Secretary*). This committee handles subjects which do not logically fall within the scope of other committees on communications. The committee reviews and arranges presentation of papers which cover a wide range of interest. For example, in the past year there have been papers concerning audio-frequency filters, frequency stabilization, radio dispatching systems, and narrow-band speech spectrums.

The committee in past years has arranged for technical and joint technical sessions with other committees. At the present time there are a sufficient number of papers to warrant sponsoring an independent technical session at the coming Winter General Meeting. This session will be concerned primarily with design and application of filter circuits.

This committee has not met recently but a meeting is planned for some time during the Winter General Meeting.

General Applications Division

Committee on Marine Transportation (*J. B. Feder, Chairman; W. E. Jacobsen, Vice-Chairman; W. N. Zippler, Secretary*). Two meetings of the committee were held, on June 27 and October 10, 1952. The 1951 revision of Standard Number *45*, "Recommended Practice for Electrical Installations on Shipboard," had been made available to the public in the early part of 1952, and it was evident from the subjects discussed at these meetings that the changes made from the 1948 revision of the Standard were well received.

Some time ago the committee decided to add a new section to the Standard covering Galley Equipment, and a special subcommittee was appointed to correlate such data. The report of this subcommittee has finally been adopted and the next revision of the Standard is expected to contain these data.

A special subcommittee was appointed for the purpose of initiating steps and carrying to a conclusion the assignment of a session at, and the preparation of papers for, the January 1954 Winter General Meeting of the Institute devoted exclusively to papers on suitable marine electrical subjects.

The next meeting of the committee will be held in the spring of 1953.

Industry Division

Committee on General Industry Applications (*V. O. Johnson, Chairman; F. D. Snyder, Vice-Chairman; E. M. Hays, Secretary*). The Rubber and Plastics Subcommittee announces that it will extend its annual technical conference in Akron, Ohio, next spring to 2 days with a banquet and entertainment in the evening of the first day, and will add an inspection trip to one of the local industries the afternoon of the second day.

The Textile Subcommittee, in addition to

its annual northern and southern conferences each spring, is this year staging a third meeting in Raleigh, N. C., Thursday and Friday, November 6 and 7. The northern meeting will follow the AIEE North Eastern District Meeting to be held in Boston, Mass., April 29–May 1, 1953. The "textile" portion of the program will be an all-day session on May 1, including a luncheon. While it coincides in time and place it will be a separate Conference of the Textile Subcommittee. The Southern Textile Conference will be at the Georgia Institute of Technology in Atlanta, but no date has been set.

The customary 3-day conference of the Machine Tools Subcommittee will be held at the Ten Eyck Hotel, in Albany, N. Y., October 29–31. Valuable technical papers and inspection trips are planned.

The Materials Handling Subcommittee, while not planning a technical conference, is sponsoring a session at the Winter General Meeting in 1953 on the subject of high-speed elevators. This promises to be an interesting session.

The Pulp and Paper Subcommittee has no definite plans but is considering ways of reaching the people in the industry who are generally not members of AIEE. Since the industry is so widely scattered, a plan to prepare a "package conference" and carry it to the industry by means of small local meetings over the country is now being considered.

Committee on Industrial Control (*J. A. Cortelli, Chairman; H. L. Palmer, Vice-Chairman; L. H. Matthias, Secretary*). This committee is planning a session on the general subject of the "Co-ordination of Control," both high voltage and low voltage, with present-day industrial voltage systems, and another on the subject of "Packaged Drives" at the Winter General Meeting to be held in New York, N. Y.

The first-mentioned session is a subject of considerable interest at the present time because of the larger industrial systems being made available and the possible destructive effect on equipment during a fault on such systems. Furthermore, the development of high-rupturing-capacity fuses and the promotion of the use of these fuses on systems has brought to the forefront the many problems and considerations that must be considered in the application of electric control in industrial plants.

The second session will be concerned with the many applications that are being covered today with what has become known in the industry as packaged control equipment.

Both of these sessions should be of considerable interest to electrical engineers who must concern themselves with the application of control in their plants.

The committee has further initiated contacts with the various committees in the Industry Division in an endeavor to arrange for mutually sponsored sessions covering applications in specific industries. The proposal has met with considerable enthusiasm expressed by the various Industry groups and it is hoped that future technical sessions or conferences can be sponsored with these groups to discuss the various phases of industrial control to meet the needs of the different industries.

Power Division

Committee on Protective Devices (*H. R. Stewart, Chairman; A. A. Johnson, Vice-Chairman; E. H. Yonkers, Secretary*). This committee has approved by letter-ballot the revised "Application Guide for Ground Fault Neutralizers" and "Application Guide for the Grounding of Synchronous Generator Systems"; and these have now been submitted to the Committee on Technical Operations for presentation by title only at the Winter General Meeting to secure any further discussion, and to the Standards Committee for approval and issue as an AIEE Standard publication. The printing of these guides will fill a frequently expressed need. The third in this group of revised guides, "Application Guide on Methods of Neutral Grounding of Transmission Systems," is in the letter-ballot stage.

One of the problems which the Working Group on Revision of the AIEE Lightning Arrester Standard Number *28-A* is considering, is a more satisfactory scheme of arrester classification than "station," "line," and "distribution" types. Any suggestions from the interested membership will be welcomed.

Two papers presented at the Fall General Meeting are of interest to protection engineers concerned with the surge protection of large unit-connected generators. These papers describe field tests and transient analyzer studies indicating that large high-speed turbogenerators having single-turn armature coils are to a considerable degree self-protecting against lightning surges arising on the high-voltage system, provided the transformer bank is Y-delta connected and itself adequately protected in its high-voltage side.

Organization work is well under way with two working groups, one studying the lightning protection of aerial cables, and the other studying means of reducing ground resistances.

The "Application Guide on Lightning Protection of Substations" is approaching final form and is awaited with interest by protection engineers to fill a long-felt need.

Committee on Relays (*A. J. McConnell, Chairman; W. E. Marter, Vice-Chairman; Frank von Roeschlaub, Secretary*). A West Coast subcommittee has been set up under the chairmanship of M. A. Bostwick, with Cort Lowrison as vice-chairman, to serve as a clearing house for ideas and comment on relaying from those members of the Committee on Relays who cannot always attend the regular meetings of the latter. This group will organize and solicit papers for relay sessions at Institute meetings on the West Coast, and will also expedite project committee activity, such as the preparation of replies to questionnaires from that area.

In consideration of the proposed revision of the paragraph on short-circuit requirements of synchronous generators of the American Standards Association *C-50* standards for rotating machinery, a new project committee has been set up to study the relaying requirements established by this revision. This Project Committee on the Protection of Generators on Unbalanced Current, with G. W. McKenna as chairman, is sponsoring four papers on this general subject, one of which was presented at the Fall General Meeting in New Orleans in October and the remaining three of which will be scheduled for the Winter General Meeting in January.

Three committee reports are also planned for presentation at the Winter General Meeting, on work that has been completed by the Project Committees on Remote Tripping, Back-up Protection of Transmission Lines, and Pilot Wires.

AIEE PERSONALITIES.....

Nelson S. Hibshman (AM '27, M '32, F '41), Dean, School of Engineering, Pratt Institute, Brooklyn, N. Y., has been appointed Assistant Secretary of the AIEE and will join the Headquarters staff about January 5, 1953. It is expected that Mr. Hibshman will succeed H. H. Henline as Secretary of the Institute upon his retirement.

N. S. Hibshman

Mr. Hibshman has been serving as AIEE Treasurer since June 1952, and is a member of the Board of Directors. Mr. Hibshman was born on January 20, 1902, in Harrisburg, Pa., and was graduated from Pennsylvania State College with a bachelor of science degree in electrical engineering in 1924. In 1927 he received a master of science degree in electrical engineering from Lehigh University, Bethlehem, Pa., where he was a member of the faculty for 18 years. In 1942 he was appointed professor of electrical engineering and Chairman of the Electrical Engineering Department at New York University, which position he held until 1944 when he was appointed to his present position. He is a member of Eta Kappa Nu, Tau Beta Pi, and Sigma Xi. He served the AIEE as Vice-President representing the Middle Eastern District (number 2) from 1941–42 and has actively served on the following Institute committees: Instruments and Measurements (1937–39, 1942–44); Education (1941–42); Basic Sciences (1942–52); Lamme Medal (1946–49, Chairman 1948–49); Professional Group Co-ordinating (1948–49), Board of Exam-

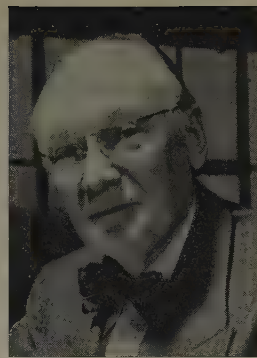
iners (1948–53); and Technical Program (1951–52).

Walter J. Barrett (M '36, F '50), Electrical Co-ordination Engineer, New Jersey Bell Telephone Company, Newark, has been elected Treasurer of the AIEE, effective January 1, 1953. He is presently serving as a Director of the Institute. Mr. Barrett was born in Brooklyn, N. Y., on January 10, 1899, and was graduated from the Polytechnic Institute of Brooklyn in 1920 with the degree of electrical engineer. Upon graduation, he entered the employ of American Telephone and Telegraph Company, Department of Operation and Engineering, and in 1924, was transferred to the staff of the transmission engineer for the company. In 1930, Mr. Barrett became a supervisor in the Engineering Department, New Jersey Bell Telephone Company, Newark, and worked in that capacity until his appointment as Electrical Co-ordination Engineer in 1943. Mr. Barrett has served on the following committees: Finance (Chairman, 1950–53); Communication Division (1950–53); Lamme Medal (1950–53); Planning and Co-ordination (1950–53); Headquarters (1950–53); Executive (1950–53); Board of Examiners (1952–53); Joint AIEE-IRE Co-ordination (1951–53); and representative on Board of Trustees, United Engineering Trustees, Inc. (1951–53). He will serve as AIEE representative on Engineers Joint Council beginning January 1,

W. J. Barrett

1953. He was secretary of the New York Section from 1945 to 1946 and chairman of the Section from 1947 to 1948. In 1948–49, Mr. Barrett was secretary of the New York City District (number 3). He is a member of Delta Kappa Pi and Tau Beta Pi.

Latimer Farrington Hickernell (AM '25, F '34), chief engineer, Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y., has been elected to the Board of Directors of the AIEE, effective January 1, 1953, to succeed W. J. Barrett. His term will end July 31, 1954. Mr. Hickernell, a native of Middletown, Pa., received the degree of bachelor of arts from Grinnell College in 1920, and that of bachelor of science in electrical engineering from Massachusetts Institute of Technology (MIT) in 1922. While in college he was employed by the Iowa Light, Heat and Power Company,



L. F. Hickernell

Grinnell, in various capacities. Upon graduation from MIT, he joined the graduate student engineer course of the General Electric Company, Lynn, Mass. In 1923 he entered the engineering department of the Consumers Power Company, Jackson, Mich., as assistant investigations engineer in the electrical department. In 1924 he became assistant investigations engineer of the successor company, the Commonwealth Power Corporation of Michigan. He became general engineer in the electrical engineering department in 1927. Stevens and Wood, Inc., succeeded this company in 1929, and in 1930 this concern was in turn succeeded by Allied Engineers, Inc. Mr. Hickernell continued as general engineer with these concerns until the disbandment of the latter organization in 1931. In that year he joined Anaconda Wire and Cable Company as electrical engineer. He became chief engineer in 1933. He is a very active member of the AIEE, having served in many capacities. Mr. Hickernell was named chairman of the newly formed Technical Operations Committee recently and has served on the following Institute committees: Electric Machinery (1929–33); Protective Devices (1929–32); Power Transmission and Distribution (1930–47); Publication (1934–35, 1951–53); Board of Examiners (1941–53); Insulated Conductors (1947–53, Chairman 1947–49); Standards (1947–49); Technical Program (1947–50); Power Division, Power Co-ordinating (1947–52, Chairman 1949–51); Planning and Co-ordination (1949–50, 1952–53); Award of Institute Prizes (1949–50); Technical Advisory (1950–52, Chairman 1951–52); and Public Relations (1952–53). He has served also on many committees of the former National Electric Light Association, the American Society for Testing Materials, National Research Council, and committees of the Insulated Power Cable Engineers Association.

E. E. Grazda (AM '42), editor, *Electrical Equipment*, Sutton Publishing Company, New York, N. Y., has joined the Hayden Publishing Corporation as editor of its new publication, *Electronic Design*. Mr. Grazda was formerly associate editor of *Electrical Engineering*. Born in New York, N. Y., September 15, 1915, he was graduated from New York University in 1942 with a bachelor of science degree in electrical engineering. He was assistant editor of *Electronics* in 1941 and 1942 and was also junior engineer with Lincoln Walsh, consulting engineer, in 1942. He joined Minneapolis-Honeywell Regulator Company in 1943 as domestic field engineer and 1 year later was named senior field engineer. He was senior technical representative on the 20th Bomber Command's *B-29* project in China and India. Also, he instructed maintenance personnel of the Central

E. E. Grazda

African Wing of the Air Transport Command and assisted in preparing postwar training program while on Okinawa. Minneapolis-Honeywell designated him design test engineer in 1945, from which post he came to the AIEE in 1947. He joined the Sutton Publishing Company in December 1949. He served on the joint AIEE–Institute of Radio Engineers Conference on Electronic Instrumentation in Nucleonics and Medicine in 1948 and 1949. He is a member of Eta Kappa Nu, the Institute of Radio Engineers, and the American Association for the Advancement of Science.

H. S. Osborne (AM '10, F '21, Member for Life), formerly chief engineer, American Telephone and Telegraph Company, New York, N. Y., has been elected president of the International Electrotechnical Commission. Dr. Osborne is president of the United States National Committee, an affiliate of the Electrical Standards Committee of the American Standards Association (ASA). He has been active in ASA work, serving as vice-president of the Association from 1949 to 1951, and as chairman of the ASA Standards Council from 1942 to 1945. He has been active on Engineers Joint Council and in the American Society for Engineering Education. Dr. Osborne retired from the American Telephone and Telegraph Company in August 1952, after 42 years of service with the company. He is a past president of the Institute (1942–43) and was a director from 1938–42. He has served on many AIEE committees including Standards, Technical Program, Education, Publication, Edison Medal, and others. He is a member of Tau Beta Pi, the American Association for the Advancement of Science, the American Physical Society, the Institute of Radio Engineers, and others.

A. A. Emlen (AM '28), sales engineer, Altec Lansing Corporation, Los Angeles, Calif., has been promoted to plant manager of the Peerless Electrical Products Division.

O. T. Ayers, Jr. (M '47), distribution engineer, Florida Power and Light Company, Miami, has been appointed manager of the company's Western Division with headquarters at Sarasota, Fla. After 6 years with Virginia Electric and Power Company, Mr. Ayers served during World War II in the Signal Corps as a captain. He joined Florida Power and Light in 1946 as engineer, subsequently becoming distribution superintendent for the Miami area and then distribution engineer for the statewide system. He is a member of the Florida Engineering Society and has served as chairman of the Miami Section of the AIEE.

A. S. Hill (AM '26), district superintendent, service and erection, Allis-Chalmers Manufacturing Company, Pittsburgh, Pa., has been named regional service supervisor of the central region with his headquarters in Cleveland, Ohio. **C. P. Suykerbuyk** (AM'45), erecting engineer, Allis-Chalmers Manufacturing Company, North Redondo Beach, Calif., has been appointed regional service supervisor of the southeast region with headquarters in Atlanta, Ga.

C. G. Goss (AM '44), development engineer in electronic circuitry, Oak Ridge (Tenn.) National Laboratory, has joined Radiation Counter Laboratories, Inc., Skokie, Ill., as director of electronic research. Before becoming a member of the staff at Oak Ridge National Laboratory, Mr. Goss was an instructor in electrical engineering at Louisiana Polytechnic Institute, Ruston.

D. S. Samuelson (AM '48), publicity supervisor and trade relations editor, Communications and Electronics Division, Motorola, Inc., Chicago, Ill., has been appointed sales promotion manager for The Hammarlund Manufacturing Company, Inc., New York, N. Y. He is a graduate in electrical engineering from Virginia Polytechnic Institute and has a master of science degree in journalism from Northwestern University. He is a member of the Institute of Radio Engineers.

J. A. Cortelli, (AM '45, M '49), chief engineer, Clark Controller Company, Cleveland, Ohio, has been elected vice-president in charge of engineering. A graduate of Case Institute of Technology, he has been with Clark since October 1934, becoming chief engineer in March 1946 and a director in April 1952. He is a member of the Association of Iron and Steel Engineers and a company representative in the National Electrical Manufacturers Association. He is vice-chairman of the Cleveland Section of the AIEE and has served on the following Institute committees: Industrial Control (1946–52, Chairman 1951–52); Mining and Metal Industry (1947–50); and Industry Division (1951–52).

W. G. Hurst (AM '51), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed a sales representative in the company's Davenport, Iowa, office. He received his electrical engineering degree from Iowa State College and recently completed the company's graduate training course.

D. H. Swanson (M '47), vice-president of marketing and sales, Line Material Company, Milwaukee, Wis., has joined the Asplundh Tree Expert Company as a director and vice-president in charge of sales.

J. W. Dzimianski (AM '51), has been appointed a research scientist at Allis-Chalmers Manufacturing Company, Milwaukee, Wis. He received his bachelor and doctor of engineering degrees from Johns Hopkins University.

OBITUARY • • • •

John Kline Tuthill (M '22), professor of railway electrical engineering, University of Illinois, Urbana, died September 15, 1952. Mr. Tuthill was born May 18, 1885, in Le Roy, Ill., and was graduated from the University of Illinois in 1914. After graduation he served as a division superintendent with the Illinois Traction System. During World War I he was an instructor in signalling and radio at the United States Army School of Military Aeronautics, Urbana. After a year as part owner of a Michigan power company, he again returned to the University of Illinois in 1920 as a teacher of railway electrical engineering. His research included railbonding and welded joints, high-speed train resistance, rolling resistance, tonnage ratings, and performance tests on locomotives.

George Wellesley Lawrence (AM '19), president and general manager, Sangamo Company, Ltd., Leaside, Ontario, Canada, died September 9, 1952. Mr. Lawrence was born in Stratford, Ontario, on October 17, 1895, and was graduated from the University of Toronto. He joined Sangamo in 1918 and held the positions of chief engineer and vice-president. He had served as president and general manager since 1936. He was elected president of the Canadian Electrical Manufacturers Association in 1948.

Lloyd Edward Tunell (AM '47), supervising engineer of the Southern Division planning section, Public Service Company of Northern Illinois, Joliet, died September 3, 1952. Mr. Tunell was born on November 8, 1904, in Alcester, S. Dak., and received his bachelor's degree in electrical engineering from South Dakota State College. He began his career with the Public Service Company of Northern Illinois in 1927. He joined the division engineering staff at Joliet in 1937.

Frederick Asher Spencer (M '37), retired, died on October 8, 1952. He had retired in June as professor and head of the Electrical Engineering Department, Norwich University, Vt. He has born in Brattleboro, Vt., April 29, 1885, and was graduated from Worcester Polytechnic Institute. He joined the Norwich faculty in 1918 and became head of the Electrical Engineering Department in 1927.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of October 16, 1952, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Abernethy, R. T., plant electrical engineer, Western Electric Co., Lincoln, Nebr.
Babb, M. A., senior engineer, Eclipse Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Burch, K. E., design engineer, National Tube Co., Lorain, Ohio
Carey, J. J., assoc. prof. of elec. engg., University of Michigan, Ann Arbor, Mich.
de Goicoechea y Plaza, L., prof. of elec. engg., Universidad de La Habana, Cuba
Detuno, R. C., plant service chief, Western Electric Co., Buffalo, N. Y.
Dishner, W. D., superintendent, Johnson City Power Board, Johnson City, Tenn.
Fenn, R. T., chief engineer, Sterling Engineering Corp., Winsted, Conn.
Hixon, J. L., sales engineer, General Electric Co., Houston, Tex.
Jones, J. N., Pacific Coast electrical supt., Westinghouse Electric Corp., San Francisco, Calif.
Koelling, W. C., supervising engineer, Joint-Adventurers-Electrical Construction, Washington, D. C.
Lee, E. M., sales engineer, General Electric Co., Seattle, Wash.
Lockett, R. H., technical field engineer, General Electric Co., Los Angeles, Calif.
MacKinnon, J. D., Jr., lieutenant, USN, Great Lakes, Ill.
McFall, E., electrical engineer, U. S. Bureau of Reclamation, Denver, Colo.
Millard, D. C., electrical engineer, Bureau of Reclamation, Denver, Colo.
Mizell, M. H., engineer, Associated Telephone Co., Santa Monica, Calif.
Morrison, R. J., inventory control supervisor, Public Service Co. of Northern Illinois, Oak Park, Ill.
Parrott, J. R., supervisor, Commonwealth Edison Co., Chicago, Ill.
Peterson, F. W., owner, Fyr-Fyter Sales & Service, St. Louis, Mo.
Ramsey, H. E., utilities supervisor, The Atlantic Refining Co., Port Arthur, Tex.
Siehr, V. P., supervising engineer, The Bell Telephone Co. of Pa., Philadelphia, Pa.
Spalding, R. D., electrical engineer, Louisville Gas & Electric Co., Louisville, Ky.
Stirnus, W. F. J., job engineer, Bechtel Corp., San Francisco, Calif.
Swift, R. A., member of technical staff, Bell Telephone Laboratories, Inc., New York, N. Y.
Thurston, E. G., Battelle Memorial Institute, Columbus, Ohio
Tribble, W. F., manager & asst. treas., Lockhart Power Co., Lockhart, S. C.
Wallis, G. F., chief electric design engineer, Colorado Fuel & Iron Corp., Pueblo, Colo.
Whaley, R. H., manager, electrical engg., Eli Lilly & Co., Indianapolis, Ind.
Wilson, L. A., electrical engineer, Bonneville Power Administration, Pittsburgh, Pa.
Worth, A. M., technical writer, Sperry Gyroscope Co., Great Neck, N. Y.
Yarnell, N. K., asst. chief distribution engineer, Southern California Edison Co., Los Angeles, Calif.

32 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before December 25, 1952, or February 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Banks, J. G. H., English Elec. Co. of Canada Ltd., St. Catharines, Ontario, Canada
Faigle, C. A. (re-election), Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
Perlman, S., Rome Air Development Center, Griffiss AFB, Rome, N. Y.
Randle, H., Calgary Power Ltd., Calgary, Alberta, Canada
Singh, K., P.W.D., Electricity Branch, E. Punjab, Simla, India
Vollum, H., Tektronix, Inc., Portland, Oreg.
Zenner, R. E., Armour Research Foundation, Chicago, Ill.

7 to grade of Member

OF CURRENT INTEREST

Power Generating and Transmission Project Is Under Construction in British Columbia

One of the most difficult power generating and transmission projects ever attempted is being constructed in central British Columbia, Canada, 400 miles northwest of Vancouver. A 50-mile transmission line will deliver power from the Aluminum Company of Canada's gigantic subterranean powerhouse now under construction at Kemano, over a mile-high mountain pass to the world's largest aluminum smelter, $2^1/_2$ miles long, which the company is constructing at tidewater at the new town of Kitimat.

Ultimately, two sets of transmission-line towers will carry the projected 1.7 million kw from the generating plant to Kitimat, but the initial contract, scheduled for completion in 1954, calls for transmission of 318,000 kw—less than a fifth of the planned generating capacity.

Since the right-of-way for the line is precipitous in the extreme and subject to heavy winds and excessive moisture combined with very low temperatures, final specifications for the job were not written until extensive studies of ice and wind loading conditions in the Kemano-Kildala pass area had been completed by Alcan engineers. Test towers with a sample conductor cable were flown by helicopter to the pass in the fall of 1950 and have been continuously recording ice and wind loadings since that time. Maximum ice load revealed by these studies to date has been 2.4 pounds per lineal foot. However, much greater loadings are anticipated because the moisture-laden prevailing westerly winds are funneled through the pass with a great degree of turbulence, resulting in a high degree of precipitation throughout the year.

About 40 miles of the line will be double-circuited over a single set of angle-steel towers. However, the 10 miles of line spanning the crest of the lofty pass will carry two sets of towers, each with a single circuit, to insure dependable service.

From the terminal switchyard at Kemano, 210 feet above sea level, a single set of 53 angle-steel towers will carry the double circuits 9 miles to a switching station perched at a 1,000-foot altitude. From this point, 88 angle-steel towers will carry one circuit over the 5,300-foot pass, while the other circuit will climb the pass via new-type aluminum tubular towers with legs having an outside diameter of 30 inches.

Since the construction work at the pass is extremely difficult, and since a second line of towers could not be safely constructed in the narrow defile of the pass with the first line already energized, both tower lines are being built now capable of carrying the entire ultimate power load of 1.7 million kw.

Once the power line has vaulted the pass, it will enter a switching station on the opposite side of the mountain at an elevation of 500 feet. From here the line will ride a single set of 145 angle-steel towers the remaining distance to the Kitimat smelter.

The double-circuited towers will carry 287-kv 1,590,000-circular-mil line with an outside diameter of 1.54 inches weighing 2.032 pounds per foot with a tensile strength of 54,400 pounds. The single-circuit towers will each bear 287-kv 3,364,000-circular-mil line. This conductor will have an outside diameter of 2.29 inches and will weigh 4.76 pounds per foot with a tensile strength of 135,700 pounds. This is the largest conductor ever fabricated and contains 108 aluminum wires wrapped around a core of steel wires. This cable is engineered to carry a radial ice and rime accumulation of 5.25 inches and a combined ice and wind load of 48 pounds per lineal foot providing a high safety factor for the extreme conditions encountered in the pass.

Longest span in the line will be between 3,000 and 3,400 feet over a glacier.

The 50-mile power-transmission-line access road is still under construction and it is rapidly being pushed through from four different points so that footings for the steel and aluminum towers can be poured this year. Engineers who know the precipitous mountain terrain already crossed by this road describe it as a major achievement in the annals of road building.

In places this road climbs almost 1,000 feet a mile reaching grades over 25 per cent and never under 15 per cent between the Kemano River valley floor and the Kildala-Kemano Pass. Extensive switchbacks, miles of rock blasting, snow, and landslides have made progress on this road slow. However, because of the remarkable feat of putting a crawler tractor on the top of the pass over steep, hard-packed snow-slides, permitting pioneer grading to be done downhill, it is expected to be finished soon.

Meanwhile, work is progressing rapidly in the vast Kemano power cavern, which will ultimately be eight stories high and two blocks long. Sometime in 1954, the initial installation of three 106,000-kva impulse turbine-generators will be completed. These units include an Allis-Chalmers turbine powering a General Electric generator, a Pelton turbine powering a Westinghouse generator, and a Dominion turbine running an English Electric generator. These three units, producing a total of 420,000 horsepower, will provide enough electricity for producing 183 million pounds of aluminum per year.

Turbine pits will extend generally 20 feet below the floor of the main chamber. The arched roof is to be lined with reinforced concrete. The possibility of leaving an air space to separate concrete curtain walls and the rock sides to prevent moisture accumulation is being studied.

The powerhouse will contain a main control room, erection bay, and space for

Future Meetings of Other Societies

American Society of Refrigerating Engineers. 48th Annual Meeting. November 30–December 3, 1952, Hotel Commodore, New York, N. Y.

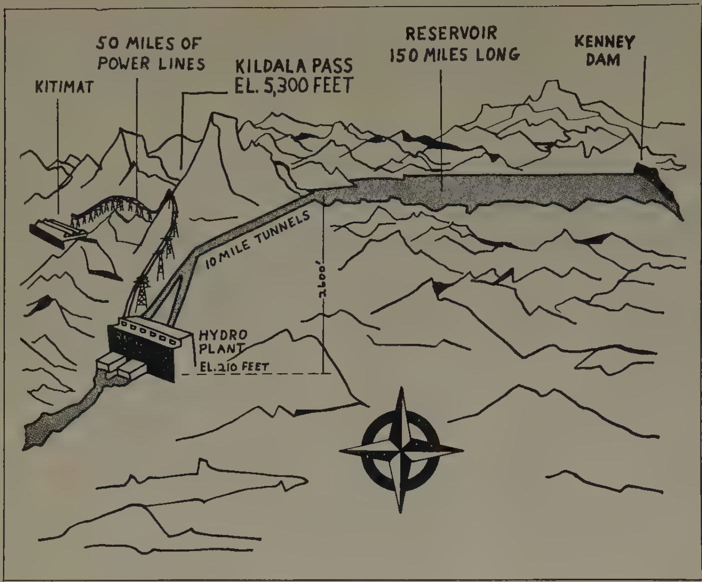
Institute of the Aeronautical Sciences. 16th Wright Brothers Lecture. December 17, 1952, United States Chamber of Commerce Building Auditorium, Washington, D. C.

National Exposition of Power and Mechanical Engineering. 20th National Power Show. December 1–6, 1952, Grand Central Palace, New York, N. Y.

Refrigeration and Air Conditioning Educational Exhibit and Conference. December 5–7, 1952, Municipal Auditorium, Miami, Fla.

The American Society of Mechanical Engineers. Annual Meeting. November 30–December 5, 1952, Hotel Statler, New York, N. Y.

Most spectacular phase of project is airlift by helicopter (right) supplying needs for mountain-top construction camp. On the left, giant aerial tramway has been installed to reach tunnel heading half a mile above the valley floor



Project British Columbia is about 175 miles from Kenney Dam on the east to the powerhouse at Kemano and the smelter and town site of Kitimat on the Pacific Coast, with a range of mountains between

eight 140,000-horsepower units. However, only the three units are planned to be installed when the first power is scheduled for transmission.

As it is impractical to carry large enough bus-bar conductors to carry the low-voltage current 1,500 feet out of the mountain, 71,000-kva single-phase transformers will be located in the powerhouse, and specially insulated conductors then will carry the high-voltage current to the transmission-line terminal.

A 1,500-foot cable tunnel will carry the conductor cable from the powerhouse cavern out to the valley floor where the switchyard is to be located. This tunnel will house some of the largest cables ever fabricated. These cables will be 300-kv oil-filled power conductors with 60 pounds per square inch oil pressure, having an outside diameter of 4 inches and containing a 515,000-circular-mil single copper conductor, paper insulated. The length of the cables will be 2,150 to 2,260 feet.

The Kemano area, hemmed in by precipitous mountains rising sharply 3,000 feet from the valley floor, is saddled with heavy snows much of the year. Snow and landslides of great force are common in this topography. This factor made it advisable to locate the powerhouse inside the mountain. Housing the units underground also facilitates anchoring of installations against tremendous water pressures. The comparative impregnability to air attack of a mountain cavern may have had some bearing on the decision. Although construction costs for this type of power-unit housing may be slightly more expensive initially, these higher costs are expected to be compensated for within a short time by lower maintenance expense.

Motor Development and Test Facility Announced by General Electric Company

A new test facility for motor engineering development has been announced by the Locomotive and Car Equipment Department of the General Electric Company in Erie, Pa. This installation, covering 20,000 square feet, is equipped to test traction motors and generators for locomotives beyond the size of any now being built.

The new facilities comprise 11 test tables, a soundproof room for noise-making tests, an air chamber for motor ventilation tests, and life-test facilities for simulating service conditions. Power is supplied from a substation which covers 4,500 square feet and is totally enclosed and isolated from the general testing area.

The 11 test tables were built with the same configuration of switches and controls to permit an interchange of operating personnel with a minimum of special instruction. Although each table has been designed to handle a particular type of equipment, enough flexibility was allowed so that each can be used to test other types as well. The latest safety features—such as deadfront switches, contactor compartment interlocks, and glass-enclosed high-voltage meters—are incorporated.

The sound testing room, in which the sound level has been reduced to the point where it will not affect the test results, is used to investigate noise characteristics and compare various designs of equipment. To reduce the ambient sound level from 90 to 60 decibels, the room has walls insulated with rock wool and floats on a 2-foot bed of sand to isolate it from the building foundation. The roof is removable to permit use of an overhead crane.

A large plenum air chamber, partitioned into two 10-foot cubicles by a steel wall containing nine standard calibrated nozzles, is used to study air-flow requirements for ventilating traction motors and generators and for studying the effectiveness of different fan and blower designs. The nine nozzles, which are made of spun aluminum, range in size from 2 to 16 inches in diameter. By opening and closing various combinations of nozzles, air flow can be accurately measured up to 30,000 cubic feet per minute.

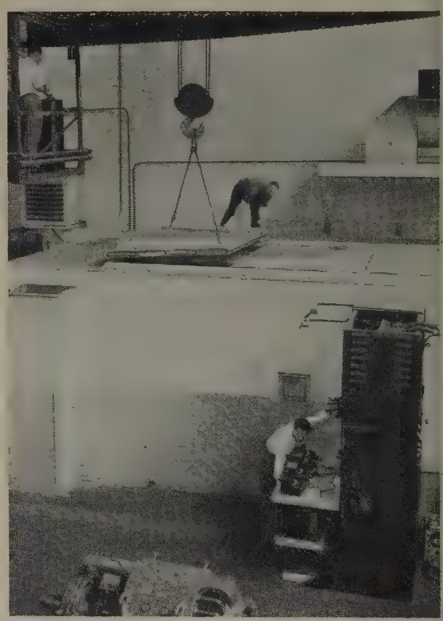
To create various conditions of intake and exhaust, large openings are provided in the front wall of each cubicle for installation of fans and test motors. The difference in static pressure between the two chambers is measured by averaging pressures from 18 different locations in each chamber. All instruments for both air flow and electrical measurements are located centrally at the test table.

The life-test facilities permit simulating actual road conditions for a wide range of equipment over varied cycles of operation. Life tests are speeded up by the use of automatic control which also permits study of fatigue and aging under operating conditions. Safety interlocks and temperature-sensitive relays protect unattended test motors. To investigate the effect of normal weather changes, motors can be tested on an outside platform.

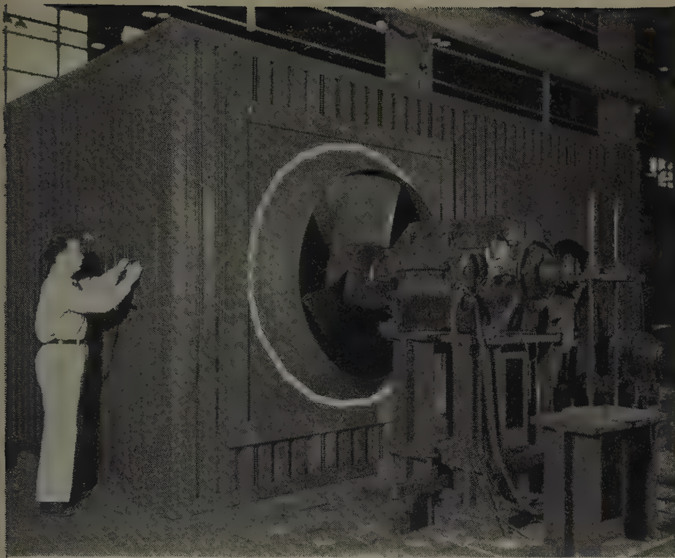
Much research will be devoted to increasing the output of traction motors and generators within the confines of the many design and size limitations inherent in locomotives. Increased output must be obtained, not by increasing the size of the equipment, but by working iron and copper more nearly to their limits. This causes greater heating, the effects of which will be studied through continuous heat runs.

Air-flow tests will include study into three areas: (1) air flow versus pressure in the commutator chamber, (2) air flow versus speed of self-ventilated machines, (3) air flow versus static heads developed at constant speeds for blowers on force-ventilated equipment.

Commutation tests will consist of varying the commutating pole flux by bucking or boosting the commutating pole field current with an external source of power. Sparking



Special sound room is fitted with removable roof sections to facilitate placing and removing equipment. To reduce the ambient sound level the room has walls insulated with rock wool and floats on a 2-foot bed of sand to isolate it from the building foundation



Fans and blowers of various types are tested in the plenum air chamber, which can measure air flow up to 30,000 cubic feet per minute

at the brushes will be measured by observation throughout the speed-load range of the equipment.

Speed-torque characteristics will be investigated by measuring generated voltage at constant speed for prescribed loads and field excitations. Constant speed can be held to within 1/8 rpm accuracy with an oscilloscope trace which is produced by modulating a fixed oscillator with the output of a tachometer generator connected to the test machine.

US Air Force Rocket Experiments Send Mammals to 200,000 Feet

The United States Air Force has disclosed that mammals were recovered alive and unharmed recently after being fired to approximately 200,000 feet in the upper atmosphere in an Aerobee rocket. This flight provided information on the reactions of mammals under conditions of zero gravity and extreme altitude. Two monkeys and two mice, the mammals involved in this flight, were recovered alive and in good health after the test at Holloman Air Force Base, Alamogordo, N. Mex.

The United States Air Force Air Research and Development Command's upper air research program has amassed a significant fund of basic scientific knowledge regarding the upper air during the past 4 years. These experiments, under the supervision of the Air Force medical scientists at Aero Medical Laboratory, Wright Air Development Center, Dayton, Ohio, were carried out at Holloman Air Force Base, and White Sands Proving Grounds, N. Mex. The testing program utilized certain rocket-type missiles, including the German *V-2* and the Aerobee. From the knowledge gained by these experiments, the Air Research and Development Command has concluded that it is possible for a mammal to function within the range of normalcy during rocket flight.

In order to study the physics of the upper atmosphere, it was necessary to perfect telemetering and photographic equipment to record the activities of the subjects during the high acceleration of take-off, the weightlessness (zero gravity) at the crest of the trajectory, and the opening shocks of descent and recovery by parachute.

The monkeys and mice experienced no unusual effects from the flight, although they were subjected to a brief initial acceleration of about 15 g, lasting less than one second, and a longer force of 3 to 4 g, lasting for 45 seconds. (The term "g" refers to the unnatural weight of an object relative to its normal weight when it is subjected to inertial forces. A force of about 15 g produces an effect on the mice and monkeys of 15 times their normal weight.)

During this rocket flight, the monkeys were anesthetized to prevent their disturbing the instrumentation necessary to record their physiological reactions.

During this rocket flight and the periods of zero gravity, the mouse in the smooth drum, floating free, appeared to have lost his senses of direction and orientation completely and was unable to direct his movements normally. However, the mouse in the drum containing a small shelf was able to cling to it, orient himself, command his body at will, and did not float in space. These reactions, plus several human experiments in jet fighter aircraft, have indicated that a man, properly secured in an aircraft, can function normally during brief periods of zero gravity and perform any operations necessary in piloting an aircraft.

These research tests have given added emphasis to Air Force belief that man will be able to withstand the unusual forces expected in rocket flight to the outer atmosphere. It is corroborated from these experiments that little or no loss of physical or mental powers would be experienced in the so-called zero gravity or weightless state encountered during brief rocket flights.

The official Air Force report on these experiments states: "Physiological results obtained with monkeys and mice can only be applied with caution to men.

"Fortunately, during the past year, two independent reports of pilot performance during states of subgravity and near zero-gravity have become available, showing no significant difficulty in performing all actions necessary to control an aircraft during an often-repeated exposure to near-zero gravity state. . . . It may be concluded that, while much remains to be done in this new area, and refined experiments are

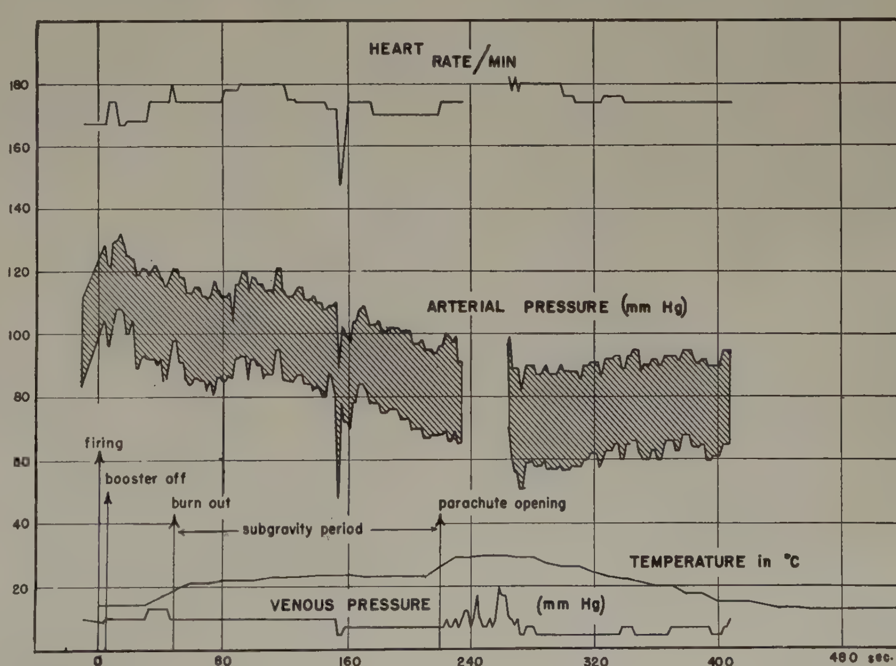


Chart shows behavior of heart rate, blood pressure of monkey, capsule temperature, and central venous pressure during the flight of Aero Medical Aerobee II to a 40-mile zenith, with successful parachute descent of the nose capsule. Abscissa time is in seconds; ordinate is in units given in legends over respective graphs

needed to determine the exact nature of the minor difficulties reported, the weightless state, as it is likely to be encountered for brief 1-to-2-minute periods in contemporary rocket and jet aircraft, will not seriously interfere with proper performance of a pilot's duties."

Electrical Insulation Conference Held at Lenox, Mass., in October

The 21st annual Conference on Electrical Insulation, sponsored by the Division of Engineering and Industrial Research, National Academy of Sciences—National Research Council, was held October 2–4, 1952, at Lenox, Mass. Over 300 participants represented the fields of physics, chemistry, electrical engineering, and ceramics from a cross section of insulation interests which include research, engineering, manufacturing, and government agencies. Formal papers and progress reports on the destruction and deterioration of insulations, followed by round-table discussions, highlighted the conference's efforts to seek improvements in dielectrics applied to all forms of electric equipment. Originally founded in 1920 in conjunction with AIEE efforts, the conference is open to all interested in insulation, and membership may be arranged through the National Research Council.

Four of the six technical sessions addressed themselves to the breakdown of dielectrics. A general paper by Dr. A. R. von Hippel, Massachusetts Institute of Technology, and chairman of the 1952 conference, reviewed earlier work on the physics of breakdown as the result of electron avalanches in crystalline materials.

Round-table discussions were held on: breakdown tests and techniques; thermal and chemical deterioration; and breakdown as a limiting factor in equipment and component design. These furnished opportunity for frank discussions between producers, designers, and users of electrical insulation to reconcile divergent approaches.

Papers on deterioration of dielectrics included discussion of the part that oxidized aldehyde solutions play in the deterioration of transformer oil; the effects of thermal degradation on plastics in which modern instruments have been brought into play to evaluate laboratory aging tests by end-product determinations.

Four papers on the deterioration and classification of dielectrics brought out the great interest in higher temperature materials involving glass, asbestos cloth, asbestos and resin, glass paper, mica, silicone-varnished glass, teflon-coated glass, and silicone rubber. These materials appear in Class *H* insulations now rated for 180 degrees centigrade copper temperature, with some indications that temperature limits of 200 degrees centigrade may be possible except for difficulties in protecting the conductor itself against oxidation failures. The Armed Services point of view was presented, with expanding temperatures in both low- and high-temperature directions for immediate use, drawing board stage, planned future and unplanned future stages. Electronic equipment, being so important in current developments, involves problems of heat dissipation, miniaturization, high humidity, thermal expansion of conductors, and need for liquid dielectrics to replace many of the solid dielectrics.

Round-table discussions followed on these subjects: maintenance of electrical insulation; classification of dielectrics; and techniques for measuring very small currents, 10^{-14} amperes being the goal.

A session on ferroelectric ceramics, such as barium titanate, and ferromagnetics in ceramics, indicated a wide new use of these materials as components for electronic equipment. The unit-function characteristic of the ferromagnetic materials used in core materials lends interest to their use in memory circuits of computers. Amplifiers are made with very small components, and bid fair to replace electronic types due to greater stability and longer life, at least in these applications.

General papers included a study of absorption in ammonia vapor, using the resonance of microwaves with high Q of 36,000; the stability of steatite dielectrics, in which calcium oxide elimination is the principal aid to stability; the dielectric constant of ice; and a continuation of earlier work on impulse breakdown for points to plane in oils, closed the conference.

Officers for the conference for 1953 are D. W. Kitchin, Simplex Wire and Cable Company, Chairman; G. T. Kohman, Bell Telephone Laboratories, Vice-Chairman; A. H. Sharbaugh, General Electric Company, Secretary.

Publications of the conference include abstracts of all papers and an annual digest of dielectric literature, both published yearly and distributed to members of the conference.

Binaural Recordings Add New Dimension to Recorded Music

A new term is about to be added to the vocabularies of the record fraternity, "Binaural records." Cook Laboratories, Stamford, Conn., has announced the perfection of a technique for producing Binaural sound on 12-inch long-playing records which is expected to make as great a difference in listening as "Cinerama" is making in viewing movies.

Binaural records are sound recorded by two "ears" simultaneously, and cut into a single record in two bands of grooves, one inside and one outside. The bands are played simultaneously by two cartridges suspended on the player arm, and received by two speakers, spaced 10 feet apart.

The effect is to add another dimension to recorded sound, and to open new fields to successful recording. It is expected that plays, for example, may be recorded in this fashion so that the realism of voice placement on the stage will be captured, which has not been satisfactorily done by single-channel records.

A characteristic of Binaural sound is that it seems louder for the same power level, and the apparent hiss noise level is correspondingly reduced. High-fidelity equipment is unnecessary with Binaural sound; actually it is found to be most spectacular when played on popularly priced instruments.

Communication Wires and Cables to Be Subject of Symposium

A technical symposium on "Technical Progress in Communication Wires and Cables" will be held December 8–10, 1952, at Asbury Park, N. J. A program is being arranged which will offer a comprehensive coverage of the field. The symposium is sponsored by the Signal Corps Engineering Laboratories.

The tentative program is as follows:

Monday, December 8

10:00 a.m. **Registration**

11:00 a.m. **Welcoming address. Introductions. Résumé of program**

1:30 p.m. **Communication Theory and Systems**

Approximately five papers will be presented on such topics as Radio Relay Systems; Lightweight Tactical Open-Wire Systems; Rural Communication Lines; Crosstalk in Cable; and Cable Transmission Characteristics

Tuesday, December 9

9:30 a.m. **Wire and Cable Constructions**

Approximately ten papers will be given on Cable Plugs and Receptacles; Wire Connectors; Pulse Cables; Shielding of Coaxial Cables; Grounding of Coaxial Cables; Drop Wire Manufacture; High-Speed Braiding; Development of Spiral Four Cable and Connector; and Inspection Policies on Quality Control Procedures.

8:00 p.m. **Banquet Dinner**

Wednesday, December 10

9:30 a.m. **Wire and Cable Materials**

Approximately nine papers will be presented on Arctic Rubber Development; Fluorothene; Polyvinyl Chloride Jackets; Depolymerized Rubber; Stainless Steel Substitutes; Water Absorption of Insulation; Fungicides in Insulation; and Moistureproofing of Splices.

Inquiries about the symposium should be addressed to Director, Coles Signal Laboratories, Signal Corps Engineering Laboratories, Fort Monmouth, N. J., Attention Milton A. Lipton.

Mobile Communications Center Ready for Civil Defense Service

An 8-transmitter mobile communications center for defense against atomic attack or any other major disaster is ready for service in Philadelphia, Pa. It was built and assembled at the RCA Victor plant in Camden, N. J.

Housed in a 23-foot by 8-foot truck, the mobile center is called the most flexible, self-contained unit ever devised for disaster work in the communications field. Before delivery of the unit, a main control center and four regional control centers had already been established in Philadelphia; but it was recognized that a disastrous atomic bombing could knock out all of these stationary centers.

Every type of modern communications is incorporated in the truck, which also generates its own electric power in order to transmit and receive messages from police, fire, and amateur radio operators. An

electric plant, powered by a gasoline engine and installed in the rear of the large truck, gives the mobile center 10,000 watts of electric power for all of its various needs.

The truck can be moved outside the city during an attack, and used to direct all work from a safe place if all other communications are destroyed or put out of operation temporarily. In the event that the normal functions of the stationary communications centers are working, the mobile unit can go directly to the scene of the disaster and relay important information to the main control center.

A crew of eight men is required to operate the mobile station which is bombproof, insulated, air-conditioned, and heated. It is furnished with the latest type of black-out curtains designed by the United States Signal Corps. It has a 70-watt public address system, four floodlights, flashing red light system, and sirens. The public address system can be heard for about five city blocks, and the horns are directional. Four sets of antenna can be raised from the roof of the truck. Cables can be connected to overhead or underground telephone wires or powerlines. Sixteen telephones are set up in the mobile unit.

If the high-line power is available, the outfit can hook in; if it is not, the electric plant generates the necessary power, or provides emergency power in case the outside power supply is cut off.

The mobile unit is equipped for 2-way communications with all police cars and also with police headquarters; it has the same communications with fire equipment and fire base stations. It transmits and receives on one Civil Aeronautics Authority frequency which will reach airplanes overhead in the Philadelphia area. It receives and transmits on three different channels reserved for amateur radio operators, both in mobile and stationary units. The mobile center reaches 117 mobile amateurs inside the city who have transmitters and receivers in their automobiles, as well as 150 mobile units outside the city limits, in addition to many amateur operators with standard equipment in stationary units in and near the city.

Electrically Operated Parking Lots Solve Problems for City Drivers

A unique parking installation, the Pigeon Hole Parking Lot, has been developed in the Pacific Northwest and is taking its place in a number of metropolitan communities.

In operation the Pigeon Hole Parking system provides for cars to be driven into ground-floor stalls, from which they are placed on the parker by means of an electric transfer carriage. The parker then rolls down the center corridor on rails, lifting the car to the proper level where it is deposited in the selected "pigeon hole." Motorists merely drive up and "check" their cars. Each car is lifted and lowered by an elevator which moves laterally as well as vertically. The same elevator and controls shuttle the car into or out of its indexed pigeon hole.

A 400-ampere main switch provides a disconnect for the control of the fast-moving operation. Fifty-eight automobiles are accommodated in a space which would normally house 16, and the system further provides for elimination of ramp and driveway area.

A 40-horsepower motor powers the hydraulic pumps used for lifting and traveling; through this combination of electric and hydraulic power a car can be parked in as little as 30 seconds. Control of all motions is handled from the operator's station and the operator moves with the car at all times, riding the platform beside the automobile so that he can see what is taking place.

The installation is notable in that it has solved the electrical problem of transmission of power to the movable hoist in an outside location exposed to weather. It also provides for the remote starting of electric motors receiving power from downtown grid systems where starting currents must be limited.

Woman Power Can Help Meet Shortage in Technical Personnel

Industry should work more closely with women's colleges to help meet the growing national shortage in technical personnel, according to Robert C. Sprague, president of Sprague Electric Company, speaking before a convocation on Science and Human Values held at Mount Holyoke College, South Hadley, Mass., October 3 and 4, 1952.

"An area of co-operation exists between women's colleges and technical industries which is now only at the beginning of its potential development," Mr. Sprague said.

Referring to the many women technical graduates who are already holding jobs in industry, Mr. Sprague expressed the view that the "nation's woman power remains relatively an untapped source in this area."

Women's colleges which now stress scientific instruction should take the initiative in providing facilities for research in highly specialized fields, he suggested. Some institutions for various reasons may be as well or better fitted than industry or a larger university to do certain levels of work, he pointed out. "Co-operative efforts of this kind are not only a service to the corporation which underwrites the project, but the stimulus of research invigorates teaching and awakens the interest of the serious student in science as a career. The more centers of such activity we can establish, the greater will be the numbers of qualified young women scientists and engineers to serve the nation's future needs," he said.

ASEE To Conduct Survey on Use of Engineering Library

The Engineering Societies Library, the engineering literature center, is one of the most expensive laboratory units maintained by any organization, industrial or educational. Its cost is not justified if it is not consistently used to support current operations and validate anticipated interests of an organization.

Assuming that many engineers do not extract full value from engineering literature, the Engineering Literature Project of the American Society for Engineering Education (ASEE) is trying to find out why this is true and what can be done about it. What does the practicing engineer think of the value of literature use, literature searching? Does he think it is not necessary, or, on the other hand, that it is important for an engineer to know his way around in a library?

Briefly, the Project wants to know the opinions of practicing engineers on the following points: (1) what value they place on library or literature "know-how"; (2) what training they have had in this direction; (3) whether they think such training is desirable or even essential for prospective engineers; (4) what ideas they have on the sort of training, if any, which should be given.

A questionnaire, which can be completed by simply using checkmarks in answer to the foregoing questions, is being sent to 1,000 engineers whose names have been selected at random from society and association directories. Simultaneous mailing of the questionnaire occurred Monday, November 24, 1952.

Results of this survey will be of great assistance either in developing for future engineers a form of instruction emphasizing the engineer's outlook on the use and need of literature and of library "know-how"; or in forgetting the whole thing. A copy of the questionnaire is available upon request by addressing: Engineering Literature Project, ASEE, care of E. A. Chapman, Rensselaer Polytechnic Institute, Troy, N. Y.

Nuclear Physics Conference Will Be Held in December

The National Science Foundation and the University of Rochester will sponsor an international conference on High-Energy Nuclear Physics at Rochester, N. Y., December 18–20, 1952.

The conference will bring together about 70 nuclear physicists from the United States, Canada, and Mexico to discuss recent research findings on high-energy particles and to plan future studies in this field. Investigation of high-energy particles is one of the most active research areas in physics at the present time. Such research is of fundamental importance in the release and utilization of atomic energy. The 3-day session will consider such topics as "New Unstable Particles," "Meson Production," and "Saturation of Nuclear Forces."

The scientists have been invited from university, industrial, and government and research organizations by a committee consisting of: Robert E. Marshak, chairman of the Department of Physics, University of Rochester, Rochester, N. Y., and chairman of the committee; Carl D. Anderson, Nobel laureate and professor of physics, University of Chicago, Chicago, Ill.; J. Robert Oppenheimer, director of the Institute for Advanced Study, Princeton, N. J.; Bruno Rossi, head of high energy research, Massachusetts Institute of Technology, Cambridge, Mass.; Eugene P. Wigner, professor of theoretical physics, Princeton University, Princeton, N. J.; John A. Wheeler, professor of theoretical physics, Princeton University, Princeton, N. J.; and Raymond J. Seeger, program director for physics and astronomy, National Science Foundation, Washington, D. C.

Enrollment Increase Reported by Georgia Tech

A total enrollment of 3,775 day-school students for the 1952 Fall Quarter at the Georgia Institute of Technology, Atlanta, Ga., has been announced by the Registrar, W. L. Carmichael.

This is an increase of slightly over 5 per cent as compared to the enrollment figure for the same period last year. Of the 3,775 total, 1,131 are new students of which 890 are freshmen.

Out of 485 veterans, 107 are veterans of the Korean war. Thirty-eight different countries are represented by 179 foreign students, and for the first time in its history, two women engineering students are enrolled in the day school.

The School of Mechanical Engineering has the largest number of students enrolled with a total of 626. Electrical Engineering is second with 616 and Industrial Management third with 583.

Nuclear Research Laboratory to Be Built in Switzerland

Thirty nuclear physicists from ten European nations met October 4–7, 1952, in Amsterdam, Holland, and unanimously selected a site near Geneva, Switzerland, for a European nuclear research laboratory.

The laboratory is to house what may be the most powerful atom-smashing cosmotron in the world, a huge accelerator that will be rated at 30 billion electron volts. There will also be a synchro-cyclotron with a rating of 600 million electron volts.

The laboratory will take about 7 years to build and equip and will cost the participating countries an annual total of almost 4 million dollars. It is to be used exclusively for pure scientific research. None of the results will be secret but will be supplied freely to all member nations of the European Council for Atomic Research, an organization founded recently with the help of the UNESCO.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Rotating Machine Oscillator

To the Editor:

I have read with interest the article by H. Gomberg on "An Analysis of the Series Generator—Shunt Motor Oscillator" (*EE, Jul '52, pp 639–41*), but I am somewhat surprised to learn that a search of the literature failed to reveal a theoretical discussion of this now venerable experiment.

It was originally described, without explanation, by Gérard-Lescuyer.[1] The theory has been given by B. van der Pol,[2] who has shown that the performance of the machines leads to a nonlinear differential equation which is well known in the theory of relaxation oscillators. A brief account was given by P. le Corbeiller in the *Journal* of the Institution of Electrical Engineers in 1936,[3] and in greater detail by Dr. N. W. McLachlan in his book.[4] This book also gives a considerable bibliography on this and related problems.

B. HAGUE (M '30)

(Professor of Electrical Engineering, Glasgow University, Glasgow, Scotland)

REFERENCES

1. Sur un paradoxe électrodynamique, **Gérard-Lescuyer.** *Comptes Rendus*, volume 91, 1880, pages 226–7.

2. **B. van der Pol.** *Zeitschrift fuer Hochfrequenztechnik*, volume 114, 1927, page 29.

3. The Nonlinear Theory of the Maintenance of Oscillations, **P. le Corbeiller.** *Journal*, Institution of Electrical Engineers (London, England), volume 79, 1936, pages 361–78.

4. Ordinary Nonlinear Differential Equations in Engineering and Physical Science (book), **N. W. McLachlan.** Oxford University Press, London, England, 1950. Pages 47–8.

To the Editor:

In Mr. Gomberg's "An Analysis of the Series Generator—Shunt Motor Oscillator," it is stated that a demonstration of this oscillator inspired students to search the literature for a theoretical discussion of this phenomenon and that the search proved fruitless. An analysis of the system based on a linear differential equation is then presented.

Unfortunately, the analysis of this phenomenon based on a linear basis does not adequately explain it, since the undamped oscillations of the linear model grew indefinitely in amplitude. The attention of those interested should be directed to the existence of the following references in which a more realistic analysis that takes into account the effect of saturation is presented:

1. Mechanical Vibrations (book, second edition), **J. P. Den Hartog.** McGraw-Hill Book Company, Inc., New York, N. Y., 1940. Pages 418–20.

2. Ordinary Nonlinear Differential Equations in Engineering and Physical Science (book), **N. W. McLachlan.** Oxford University Press, London, England, 1950. Pages 47–8.

The analysis of the series generator—shunt motor oscillator presented in these references explains the observed facts and indicates that the oscillations of the system are of the "relaxation" type.

L. A. PIPES (M '50)

(University of California, Los Angeles, Calif.)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

LA COMMANDE ELECTROMAGNETIQUE ET ELECTRONIQUE DES MACHINES—OUTILS. By A. Fouille and J. Canuel. Dunod, Paris, 1952. 340 pages, charts, diagrams, illustrations, tables, 9$^3/_4$ by 6$^1/_2$ inches, bound. Ffrs. 3,250. Motors as machine-tool drives are treated from a general standpoint in the first section with particular attention to speed regulation. In the second section the choice of motor based on motor characteristics is discussed in detail, including basic drive systems for various purposes. Section III covers the fundamentals of electronics, describes electronic, magnetic, and electromagnetic servomechanisms for machine-tool operation, and gives practical examples of current commercial equipment.

LINCOLN'S INDUSTRIAL-COMMERCIAL ELECTRICAL REFERENCE. By E. S. Lincoln. The Electrical Modernization Bureau, Inc., 110 Mamaroneck Avenue, White Plains, N. Y., second edition, 1952. Twenty-six sections, various pagings, diagrams graphs, illustrations, tables, 11$^1/_4$ by 8$^1/_2$ inches, bound. $25. The entire field of industrial electrical operations, from service entrance through utilization equipment, is covered in this reference book. The material is divided into sections containing tables, diagrams, illustrations, and descriptions of typical equipment in the respective fields, and other practical information. Special sections cover electrical and other related associations, and provide indexes to the National Electrical Code and NEMA Standards. The revision has been done in accordance with the results of a study of questionnaires filled in by owners of the first edition.

MEASUREMENTS AT CENTIMETER WAVELENGTH. By Donald D. King. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y., 1952. 327 pages, diagrams, charts, illustrations, 9$^1/_4$ by 6$^1/_4$ inches, bound. $5.50. This combination text and reference work provides a thorough and detailed treatment of the subject, emphasizing the importance of transmission-line theory in centimeter-wave measurements. In the book the term "centimeter wave" is used to include roughly the wavelength range from 3 meters to 10 millimeters. The main divisions of the book are as follows: transmission of power at centimeter wavelength; measurement of centimeter-wave power; frequency, wavelength, and waveform measurement; generators; impedance and radiation measurements.

THE MILLION DOLLAR LECTURE AND LETTERS TO FORMER STUDENTS. By Erwin Haskell Schell. First edition, 1952, McGraw-Hill Book Company, 330 West 42d Street, New York 36, N. Y. 177 pages, bound. $3. This book presents a selection of letters to the graduates of the author's department at Massachusetts Institute of Technology, together with a new version of a lecture given each year to the senior students. The author deals with the business executive's responsibility both to himself and to the society and the business world of which he is a part. A blend of philosophical and practical advice is offered to the young man starting a business career.

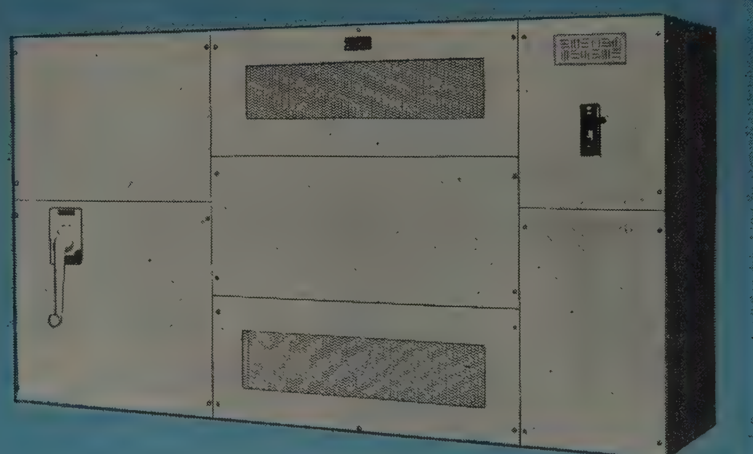
STATISTICAL THEORY WITH ENGINEERING APPLICATIONS. 783 pages, charts, tables, 10$^1/_4$ by 6$^3/_4$ inches, bound. $9. STATISTICAL TABLES AND FORMULAS. 97 pages, tables, 11 by 8$^3/_4$ inches, paper. $2.50. By A. Hald. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. The author's aim has been to cover a large part of the theory developed during the past 50 years and proved to be of practical value The subject is treated necessarily from a mathematical standpoint, but each important theorem or aspect is illustrated with examples from actual experience. The main stress is laid on the normal distribution and the tests of significance connected with it. Published in conjunction with the text is a separate volume containing a comprehensive set of statistical formulas of practical importance and tables containing standard statistical functions. In addition to the full treatment in the book itself a great many notes and references to further material on the subject of statistical formulas are included.

For Unit Substations

Uptegraff Dry Type Transformers

Complete with enclosure

Uptegraff Dry Type Transformers for Unit Substations are furnished in standardized sizes and ratings from 112.5 KVA to 2000 KVA, 5 to 15 KV inclusive. They are furnished with sturdy, well-ventilated steel enclosure if complete unit is desired. Terminals can be top or side mounted.



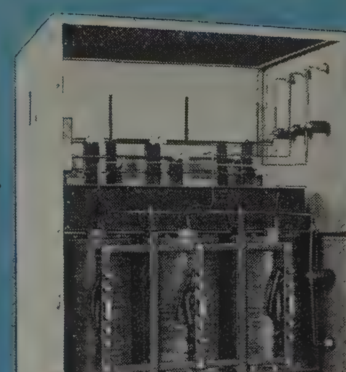
Core and Coil Assembly only

For building into a complete substation enclosure, Uptegraff furnishes dry type the core and coil assembly alone, with rigid clamping frame and sturdy terminal construction. All Uptegraff dry type transformers are designed and built for dependable service. They are mechanically strong and electrically efficient.

Above is shown a dry type Uptegraff substation power transformer. Fully protected by steel enclosure, yet ample provision for ventilation.

***Right*—Substation transformer with front cover removed, showing H. V. Terminal arrangement.**

***Below*—Uptegraff Core and Coil assembly for installation in unit substation.**



R. E. Uptegraff Manufacturing Co.

Scottdale, Pa.

INDUSTRIAL NOTES ....

US Rubber Appointments. Dr. John McGavack has been appointed technical director of the plantation division of United States Rubber Company. Dr. McGavack, who will direct the division's research and development work, has been with the company since 1920.

Purdy Miller has been appointed manager of molded goods sales. Formerly manager of the Chicago, Ill., branch, he will make his headquarters in Passaic, N. J.

H. W. Willard has been appointed factory manager of United States Rubber Company's Passaic plant, succeeding W. C. Bowker, who is retiring. Mr. Bowker recently completed 47 years of service with the company. Mr. Willard, a graduate of Cornell University, entered the company's employ in 1929.

New Measurements Corporation Plant. The purchase of an additional plant has been announced by Measurements Corporation of Boonton, N. J., manufacturers of precision electronic instruments. The newly acquired property is located in Randolph Township, N. J., 12 miles from their main location, and consists of a modern building with 15,000 square feet of manufacturing space on a 72-acre tract.

Bendix Names Mobile Head. L. J. Straw has been named Mobile Sales Manager of the Bendix Radio Division of Bendix Aviation Corporation. In his new capacity Mr. Straw, who joined the company in February 1952, will head a newly created national sales engineering organization, selling the Bendix line of 2-way radio and communications systems. He previously was associated with Capehart-Farnsworth Corporation, and with Raymond Rosen Engineering Products in Philadelphia, Pa.

Fisher Joins Lenkurt. W. C. Fisher has joined the sales engineering service section of the Lenkurt Electric Company, San Carlos, Calif., where he will be concerned primarily with applications of carrier channelizing equipment for point-to-point radio systems. Before joining Lenkurt, Mr. Fisher was vice-president of Norwesto Communications Ltd., Kenora, Ontario, Canada. He is a graduate of the University of Saskatchewan.

Moloney Plant Addition. A new transformer plant addition for the Moloney Electric Company, St. Louis, Mo., has been completed adjacent to the company's existing plant. A 1-story steel structure of the standardized rigid-frame type, providing 19,200 square feet of manufacturing area and 10,800 square feet of materials handling area, the plant was designed and fabricated by the Luria Engineering Company. The building is designed to handle two 5-ton bridge cranes and has an open runway for one crane that is 240 feet long.

Brush Development Officers. D. C. Lynch has been elected vice-president in charge of sales of The Brush Development Company, Cleveland, Ohio. Mr. Lynch was formerly senior staff executive of Willys Overland in Toledo, Ohio. Prior to that he had been with the Westinghouse Electric Corporation.

A. J. W. Novak, formerly manager of the Instrument Department, Sales Division, has been appointed assistant general sales manager. He is a graduate of Harvard University and has been with the company since 1946.

Allis-Chalmers Executives. J. D. Greensward has been named vice-president, director of manufacturing, general machinery division, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Previously, he was general manager of the Allis-Chalmers Norwood, Ohio, Works.

P. F. Bauer, who had been manager of the general machinery division's central sales region with headquarters in Cleveland, Ohio, succeeds Mr. Greensward as manager of the Norwood Works.

Alcoa Mining Retirement. L. R. Branting, works manager of the Alcoa Mining Company's Bauxite, Ark., operations, has retired after more than 32 years of active service with the company. Mr. Branting was instrumental in organizing the Bauxite operations and had been in charge until his retirement of all bauxite mining in Arkansas.

J. T. Watters, assistant works manager, succeeds Mr. Branting as manager. Mr. Watters, who was graduated from the Georgia Institute of Technology in 1923, has spent his entire business career with Alcoa.

IT&T Appoints Knight. Appointment of G. C. Knight as assistant to the president of International Telephone and Telegraph Corporation, New York, N. Y., has been announced. Active in management and industrial relations since 1941, Mr. Knight comes to the company from its subsidiary, the Capehart-Farnsworth Corporation, where he had served successively as assistant to the president, division manager of research and development, and operations manager of the commercial products division.

NEW PRODUCTS ..

Miniature Thermostat. A surface thermostat has been developed by the Richard Fonovits Company that reportedly is the "world's smallest thermostat." Its base, $1\frac{11}{32}$ by $1\frac{3}{16}$ inches, serves as the thermosensitive element which reacts to the temperature changes of the medium to be controlled. The thermal flux is transmitted to a bimetal spiral which in turn operates the switch fitted with silver contacts. To obviate frictional losses, a miniature ball bearing is provided.

(*Continued on page 24A*)

POWER COSTS

3 WAYS

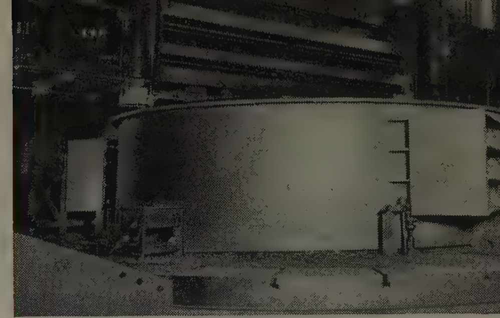
WITHOUT SURFACE CONDENSERS, low-cost steam-generated electric power would not exist. By maintaining a vacuum at the turbine exhaust, condensers increase plant efficiency and power output. By condensing steam for reuse, they minimize feedwater requirements and costs.

In installation after installation, Allis-Chalmers condensers have given outstanding performance. They are tailor-made for each particular installation. They incorporate design features that provide continuous unbroken operation. And they have consistently cut power costs by maintaining:

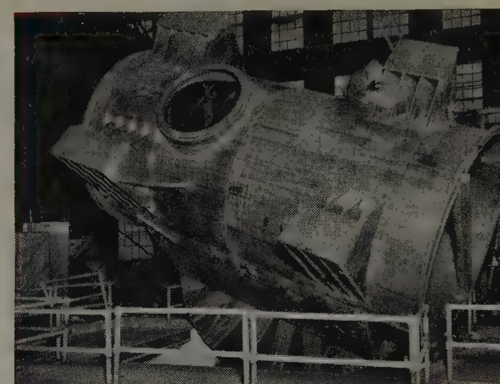
1. Lowest practical absolute pressure obtainable with the water temperature available.
2. Highest "terminal-difference" efficiency; that is, the temperature of the cooling water leaving the system most nearly approaches the temperature of the steam in the condenser.
3. Highest possible condensate temperature.

The engineering behind these cost-cutting, multi-steam-path condensers results from more than 60 years of condenser building experience. Since the days of the early steam engines, Allis-Chalmers has produced more than 13,000,000 sq ft of condenser capacity — for all areas of the country and for all types of water conditions.

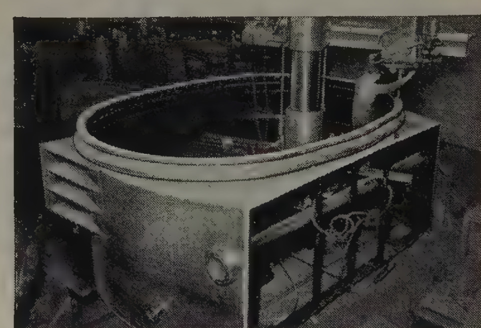
Whether you need a 500 sq ft or a 100,000 sq ft condenser, you can benefit from this experience — and from A-C's unexcelled manufacturing facilities. Why not discuss your requirements with your nearby A-C representative. Allis-Chalmers, Milwaukee 1, Wisconsin. A-3813



Adequate manufacturing facilities assure accurate machining and assembly. Here, a 40-ft mill easily handles end section of a 75,000 sq ft condenser.



Special welding positioner produces sound welds by permitting operator to work in natural position.



Drilling bolt holes in flange of large oval shell section requires modern facilities so parts will fit precisely.

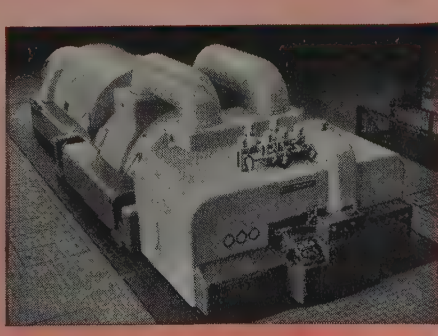
CHALMERS

A-C ALLIS-CHALMERS

Ask your A-C representative for Bulletin 19B6784, which shows how Allis-Chalmers builds these cost-cutting condensers.

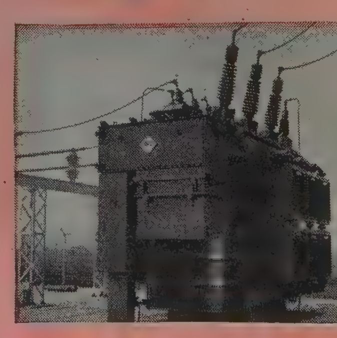
First Generator with Supercharged Cooling

In this operation-proved turbine-generator, *supercharged* hydrogen passes through rotor conductors. *Supercharging* increases output per unit size . . . cuts foundation costs, plant size, and breaker and bus structure requirements.



Transformers with Corona-free Design

To check insulation aging, A-C transformers are designed to be corona-free even at highest test voltages. Without corona, your transformers stay young; repeated voltage stresses do not cause progressive deterioration of insulation.



(*Continued from page 18A*)

Switching ON and OFF is performed within 0.01 second; no arcing or interference with radio reception occurs. Contact rating of the thermostat is 2 amperes on 200 volts alternating current; temperature differential is ±3 degrees Fahrenheit; it is shock and vibration resistant as high as 7 g. Additional information is available from the Richard Fonovits Company, Vienna, Austria.

High-Sensitivity Inverter. The development of a synchronous inverter with a sensitivity of 0.05 microvolt and a dissymmetry of less than 1/2 of 1 per cent has been announced by The Bristol Company, Waterbury, Conn. Known as the Bristol Syncroverter Switch, this inverter is capable of converting low-power d-c signals to alternating voltages that can be amplified and applied to electronic, electric, and servo systems. The switch will operate at any frequency from zero to 3,500 cycles. Errors due to thermal electromotive force are eliminated by two single-pole double-throw contacts. The inverter is free from resonance effects and is hermetically sealed against dust and corrosion.

Ohmmeter and Leakage Tester. A new combined ohmmeter and leakage tester has been announced by the Southwestern Industrial Electronics Company, Houston, Tex. The Model *C-3* Resistance Meter is a compact, portable instrument designed for production testing of transformers, capacitors, and so forth, with a useful range of 1 ohm to 1,000,000 megohms. The four ohmmeter ranges are powered by a 1 1/2-volt battery. The six megohm ranges apply a maximum of 105 volts to the unit under test, providing a quick and accurate indication of insulation resistance or dielectric leakage. Accuracy is ±3 per cent of full-scale deflection for all ranges except the highest megohm range which is ±5 per cent.

High-Voltage Ceramic Capacitors. Voltage ratings of from 1 to 20 kv are now available in ceramic capacitors of the slug, disk, plate, and tubular types offered by the Hi-Q Division of Aerovox Corporation, Olean, N. Y. In the slug type utilizing thick disk dielectrics, the strength of the capacitor is greatly increased by an exacting jacketing procedure in conjunction with a newly developed plastic that provides excellent arc-resistant properties. Terminals are silvered brass integrally soldered to silver electrodes fired directly to the ceramic dielectric. Insulation resistance is of the order of 50,000 megohms. Working voltage is 20,000 volts direct current, and flash test is 27,000 volts direct current. The high-voltage tubulars have been developed specifically for use in horizontal sweep and deflection sections of television receivers, and come in standard capacitances from 4.7 to 1,000 micromicrofarads, voltage pulse ratings of 1 to 7 kv, and capacity tolerances of ±5 per cent.

(*Continued on page 32A*)

(*Continued from page 24A*)

Wide-Band Microwave Receivers. Polarad Electronics Corporation has announced the first wide-band microwave receivers. A series of four instruments are available covering the frequency range from 1,000 to 10,750 megacycles. The receivers have high sensitivity and wide tuning range. Triple-tuned radio-frequency preselection insures high image rejection while high order of gain stability permits application as a field intensity meter. Frequency stability permits accuracy of reading of better than 2 per cent. The receivers include features such as linear decibel indication, single dial tuning, low noise figure, amplitude and frequency modulation reception, and automatic frequency control. The video bandwidth is such that a 1-microsecond undistorted pulse of 10 volts will appear across an output impedance of 100 ohms. Complete information is available from Polarad Electronics Corporation, 100 Metropolitan Avenue, Brooklyn, N. Y.

Field Strength Meter. A new ultra-high-frequency–very-high-frequency Field Strength Meter introduced by Erwood, Inc., Chicago, Ill., was designed to determine the strength of signals available at any given location. It covers all frequencies used today in broadcasting television and frequency modulation programs, and is useful in determining relative efficiency of different types of antennas as well as the optimum height. The very-high-frequency range is continuous from 52 to 218 megacycles, with sensitivity at 60 per cent meter deflection per 100-microvolt input. Ultrahigh-frequency range is continuous from 470 to 890 megacycles, with sensitivity at 50 per cent meter deflection per 100-microvolt input. Eleven tubes are used and power consumption is 70 watts, 110 volts alternating current.

Decade Inductors. New Lenkurt Decade Inductors are now available with inductance values guaranteed to within 1 per cent. Four individual units cover the ranges from 1 to 10 millihenrys, 10 to 100 millihenrys, 100 millihenrys to 1 henry, and 1 to 10 henrys. All four units are also available as a single unit to cover the complete range from 1 millihenry to 10 henrys. Moisture-resistance impregnated inductors are wound on molybdenum permalloy toroidal cores for high-Q and low external pickup. Each decade had complete electrostatic shielding. Full rotary switches for selecting inductance values have low contact resistance, laminated self-wiping contacts, and positive detents. Further details for Type *DE* decade inductors are given in Lenkurt Bulletin *DE-P2*, available from Lenkurt Electric Company, 1101 County Road, San Carlos, Calif.

Precision Pulser. The Radiation Counter Laboratories Precision Pulser, Mark *15* Model *47*, is a pulse generator with an extremely short rise time pulse and a precise control of pulse amplitude. The pulser is

(*Continued on page 38A*)

NOW...

full qualification approval,

MIL-M-10304 U.S. Signal Corps

--Ruggedized Meters

Weston Ruggedized Instruments (Model 1521 Class 52—300 microamperes through 8 milliamperes d-c inclusive) have received full qualification approval from the U. S. Signal Corps under specification MIL-M-10304. For full information contact your local Weston representative or write: Weston Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON **RUGGEDIZED INSTRUMENTS**

(*Continued from page 32A*)

of particular value in testing linear amplifiers and pulse circuits where a low-level signal is required. The pulse rise time is less than 10^{-8} second, fall time is 350 microseconds. The instrument has ranges of 1-, 3-, 10-, 30-, and 100-millivolt pulse amplitude with 10-turn linear potentiometer control over these ranges. Pulse height is standardized against a standard cell in the instrument. Repetition rate is 3,600 pulses per second. Further information is available from Department FP-9, Radiation Counter Laboratories, Inc., 5122 West Grove Street, Skokie, Ill.

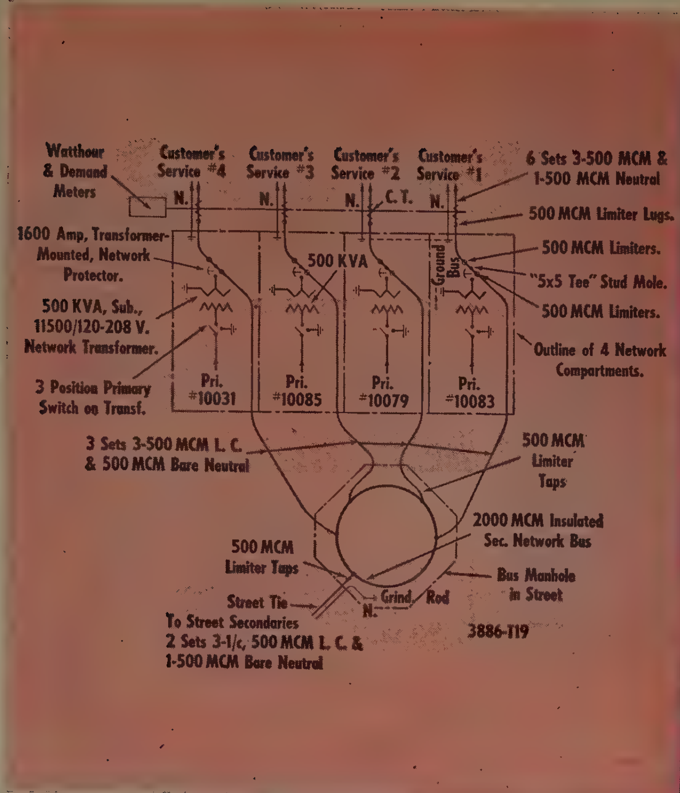
Subminiature Triode. Raytheon Manufacturing Company announces a new low microphonic subminiature triode designated *CK6247*. This type has a maximum noise output of 2.5 millivolts alternating current across 10,000 ohms in the plate circuit when the tube is subjected to vibrational acceleration of 15 g at 40 cycles per second. Normal amplification factor rating is 60, and the mutual conductance rating 2,500 micromhos with maximum allowable plate voltage of 275 volts. Data and further information may be obtained from Raytheon Manufacturing Company, Technical Information Service, Special Tube Section, 55 Chapel Street, Newton 58, Mass.

Switch Assemblies. Production of precision toggle switch assemblies of a new type for multiple-circuit control is announced by the Micro Division of Minneapolis-Honeywell Regulator Company. The assemblies are available with from 1 to 10 double-throw switching elements, all operated by a single lever. The lever may be detented in the center, and either or both extreme positions, or may be self-returning to the center. Each switching element is Underwriters' Laboratories listed at 10 amperes up to 250 volts alternating current, and will handle 30-volt d-c inductive loads at 10 amperes at sea level and 6 amperes at 50,000-foot altitudes.

Selenium Diodes. Two new selenium diodes, *1S1* and *5U1*, have been developed for addition to the line of subminiature diodes produced by International Rectifier Corporation. The *1S1* is rated for a maximum input of 26 volts rms at 100 microamperes output, while the *5U1* is rated for 130 volts maximum at 1.5 milliamperes. The units are completely encapsulated within a thermosetting plastic to protect them against adverse environmental conditions. The output voltages available by the use of these diodes are 20 volts to 100 volts at currents of 100 microamperes to 1.5 milliamperes. Additional data are available from the International Rectifier Corporation, 1521 East Grand Avenue, El Segundo, Calif.

RCA Tubes. The Tube Department of the Radio Corporation of America has announced the development of the following tubes. The *5726* is a high-perveance,

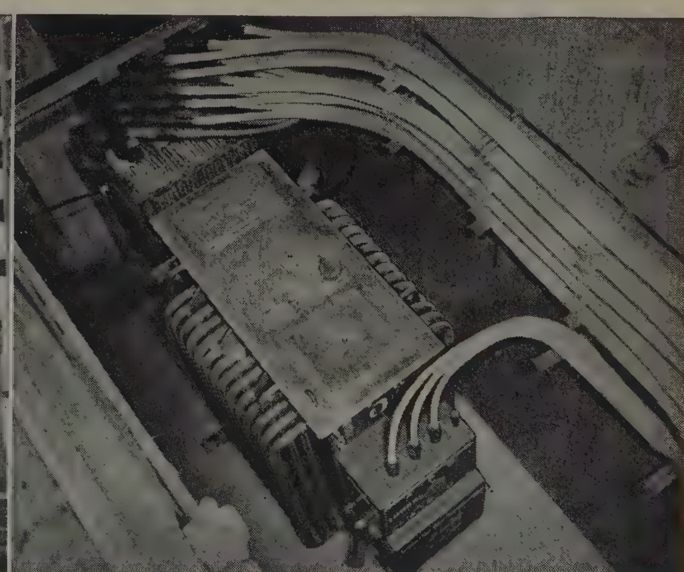
(*Continued on page 52A*)



Single-line schematic diagram shows the network system designed for each of the Gateway buildings. Transformers are tied into the Duquesne Light Company's secondary network system, but the distribution pattern within each building is a radial system.

Down she goes. This 500-kva sealed network transformer is one of ten Allis-Chalmers designed units that are now serving the Gateway Center. Five buildings still in the planning stage will have means of expanding to accommodate additional transformers of higher kva rating.

This 750-kva network transformer is lowered into its vault by a Duquesne Light Company crew. Accessories are located to give maximum convenience for periodic inspection. Special surface treatment cuts maintenance.



Pittsburgh is sure to continue to grow. And to allow for future load growth, Duquesne Light Company engineers designed these vaults to accommodate transformers of a higher kva rating. Notice the gasket-free construction.

(*Continued from page 38A*)

miniature twin diode especially useful as a detector in circuits utilizing wide-band amplifiers. The two coiled heaters used in the *5726* are internally connected in series to provide fail-safe operation in applications which require that burnout of either heater will make the heaters of both units simultaneously inoperative. These heaters employ pure tungsten to provide long life under conditions of frequent on-off switching.

Designed for general use throughout the electric systems of military aircraft, the *203W1* is a miniaturized d-c relay. Its 6-pole double-throw construction features palladium contacts rated to handle 2 amperes with a resistive load at 26.5 volts direct current and 1 ampere with an inductive load at the same voltage. Contacts are arranged in a break-before-make sequence.

A small 10-stage multiplier phototube of the head-on type, the *6199* is intended for use in scintillation counters and in other applications involving low-level large-area light sources. The spectral response of the *6199* covers the range from about 300 to 6,200 angstroms with a peak value at approximately 4,000 angstroms. Design features of the *6199* include a semitransparent cathode having a diameter of $1^1/_4$ inches on the inner surface of the face end of the bulb; a face with a flat surface 1 inch in diameter to facilitate the mounting of flat phosphor crystals in direct contact with the surface; and ten electrostatically focused multiplying stages.

The *7VP1* is a 7-inch cathode-ray tube of the electrostatic focus and deflection type designed to give sharp focus and to provide high brightness of the trace. Intended for general oscillographic applications, the *7VP1* has a small, brilliant, focused spot and high deflection sensitivity for its relatively short length. The screen is of the medium-persistence green-fluorescence type and provides high contrast.

Miniature Solderless Terminals and Connectors. A series of solderless terminals and connectors known as the Ampli-Mite series, especially designed for use in miniaturization of electronic circuits, has been developed by Aircraft-Marine Products, Inc. These terminals and connectors are made for wire sizes 26–22, and at the same time have the same features and quality as the larger AMP terminals. Due to a special AMP confined crimp, Ampli-Mite terminals can be used on stranded or solid wire. They are available in a wide variety of tongue shapes and are made preinsulated or noninsulated with or without insulation support sleeves. The insulated types have yellow polyvinyl plastic sleeves. Of particular interest are the Ampli-Mite Window connectors which are especially suited for quick permanent splices in electronic equipment, for telephone wiring, or wherever small-guage wires are to be connected. Complete information will be supplied by Aircraft-Marine Products, Inc., 2100 Paxton Street, Harrisburg, Pa.

(*Continued on page 56A*)

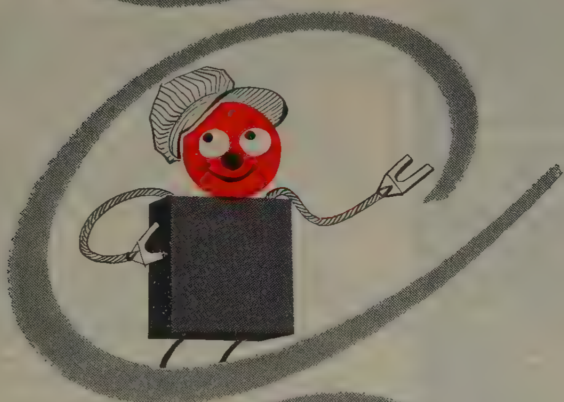
HERE'S HOW YOU SAVE TIME, CUT COSTS WITH

NATIONAL STANDARDIZED BRUSHES

TRADE-MARK

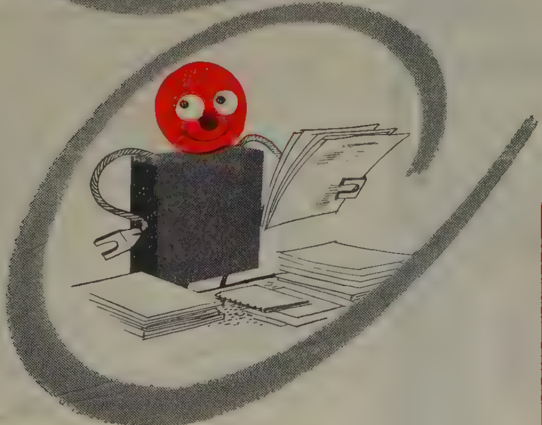
MR. ELECTRICAL SUPERINTENDENT

. . . "National" STANDARDIZED brushes greatly simplify the application of brushes to your motors and generators. You *start* right, *stay* right with brushes designed specifically for uninterrupted machine operation.



MR. MAINTENANCE MAN

. . . "National" STANDARDIZED brushes provide the ideal commutation and low friction that spell reduced maintenance cost and sustained, economical operation. Carefully controlled brush grades and tamped-type, vibration-resistant shunt connections team up to help *you.*



MR. PURCHASING AGENT

. . . "National" STANDARDIZED brushes greatly simplify ordering. They are shipped from stock—FAST—and at the same low cost for 100 or 100,000 brushes. You can carry smaller inventory . . . stock fewer *different* items — and save money in the bargain!

Write for Bulletin CP-2426
"National" Standardized Brushes

DOLLARS *and* SENSE . . .

point to "Eveready" No. 1050 Industrial Flashlight Batteries . . . delivering twice as much usable light as any battery we've ever made before. Their unique construction prevents swelling or jamming in the case . . . no metal can to leak or corrode.

The terms "National" and "Eveready" are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL STANDARDIZED BRUSHES

BETTER—PRODUCT—PACKAGE—PRICE—FASTER

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
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District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

In Canada:
NATIONAL CARBON LIMITED
Montreal, Toronto, Winnipeg

(*Continued from page 52A*)

Ventilated Square Copper Tube Bus. Ventilated square copper tube bus that provides increased current-carrying capacity for a given area of metal is being supplied by Chase Brass and Copper Company, Inc., Waterbury, Conn., subsidiary of Kennecott Copper Corporation. Ventilating holes provide air circulation for dissipation of heat from internal tube surfaces and increase alternating-current-carrying capacity approximately 20 per cent. Square copper tube provides the advantage of mechanical strength in all directions so that longer spans, without unduly large sags, are obtainable between supports. Also, large contact surfaces are provided for uniform pressure on relatively large areas for firm, secure joints that reduce oxidation. The ventilated square copper tube bus is supplied with sides ranging from 2 to 11 inches for a-c loads ranging from 1,310 to 10,600 amperes on the basis of 30-degree-centigrade temperature rise.

Vacuum Fusion Apparatus. With the type *09-1240* vacuum fusion gas analysis unit manufactured by National Research Corporation, Cambridge, Mass., a wide variety of ferrous and nonferrous pure metals and alloys including titanium, molybdenum, stainless steels, high-temperature alloys, and electronic alloys can be quantitatively analyzed for total oxygen, nitrogen, and hydrogen content. Sensitivity as high as 1 part in 10,000,000 is possible with proper operation. The system, housed in a stainless steel cabinet, is furnished complete with mechanical and diffusion pumps, mercury, furnace assembly, and built-in control panel.

Wide-Range Oscillators. Two new wide-range RC oscillators of extremely compact size and simple operation were announced recently by the Hewlett-Packard Company, Palo Alto, Calif. The new instruments have high stability and accurate, quickly resettable tuning circuits. They are mounted in an aluminum case with carrying strap for maximum portability. Model *200AB*, for general audio tests, offers a frequency range of 20 cycles to 40 kc and a full watt output. Model *200CD*, for wide-range measurements at lower power levels, provides constant voltage output from 5 cycles to 600 kc. An output amplifier provides complete isolation of the load. Frequency stability is better than ±2 per cent including warmup, and hum voltage is less than 0.1 per cent rated output.

Bonding Agent. A new bonding agent especially formulated for joining metals to each other, to similar or dissimilar metals, or to nonmetallic materials such as ceramic, glass, or wood, has been made available by the ChemoTec Division of Eutectic Welding Alloys Corporation. Available in rod, powder, paste, and liquid forms, in rod form it is applied with a welding-rod technique, but at a much lower heat. It bonds by capillary and

(*Continued on page 62A*)

(*Continued from page 56A*)

chemical action, has high fluidity, and its wetting characteristics enable the thin flowing material to penetrate all but sealed joints. Further details of the new ChemoTec Bonding Agents may be obtained from the ChemoTec Division, 172d Street and Northern Boulevard, Flushing, N. Y.

Miniature Connector Series. In the *D* Series of four miniature connectors released by the Cannon Electric Company, the contact complement ranges from 15 contacts to 50, with the smallest having an over-all length of $1^{17}/_{32}$, depth of 31/64, and width of 27/64 plus a solder-pot extension of 9/64. To provide for this compact fitting, the connectors utilize a steel shell for lighter weight, and a nylon insulator which makes possible high dielectric qualities for the gold-plated 5-ampere contacts which have a conservative minimum flashover of 1,500 volts alternating current rms. Suitable for rack and panel mounting, the series may be used as plugs on either side of the assembly by the addition of a junction shell, having an integral clamp. Advance *D-1* Bulletin, containing further information, is available from Cannon Electric Advertising Department, 420 W. Avenue 33, Los Angeles 31, Calif.

New Oscillograph. A new oscillograph designated as Du Mont Type *304-A* has been announced by the Instrument Division of Allen B. Du Mont Laboratories, Inc., Clifton, N. J. In this instrument, a built-in calibration system permits voltage measurements directly from the cathode-ray screen. The system is not restricted to measurement or sinusoidal signals, or to peak-to-peak readings, but measures any portion of the amplitude of the input signal. The oscillograph has a maximum sensitivity of 0.1 p-p volt full scale, on the 4-inch scale. In addition to its direct-reading voltage feature, Type *304-A* incorporates a new cathode-ray tube, type *5ADP*, which permits an accuracy of indication far greater than previous types and provides an extremely brilliant trace.

Steel Mill Width Gauge. A new noncontacting device which continuously and automatically measures the width of hot strip steel to an accuracy of ±1/8 inch has been announced by the General Electric Company's Special Products Section. The steel mill width gauge consists of a detector head, an operator's cabinet, and an electronic cabinet. Two phototube scanners located in the gasket-sealed detector head pick up the light radiated from the hot strip steel 15 feet below and convert it into electric signals which are two pulsating square waves. These are amplified, added together, and balanced against a standard voltage so that the difference produces a signal proportional to the width deviation. The operator's cabinet contains a 3-digit mechanical counter, a deviation indicator, and controls and switches for setting basic width and

(*Continued on page 64A*)

INSTRUMENTS FOR LABORATORIES

G-E Photolight is Used in Supersonic Speed Studies At University of Maryland

Bullets in flight at speeds from 1120 to 4000 fps are photographed with the help of a General Electric Photolight at the ballistics range in the aeronautical laboratory at the University of Maryland.

LIGHT BEAM TRIPPED

When the projectile intercepts a cross beam of light, the photolight is tripped and the exposure is made by an open-shutter camera.

HIGH INTENSITY FLASH

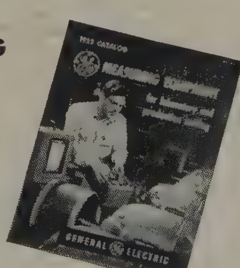
The photolight provides an extremely high intensity flash of blue-white light with a duration of approximately one microsecond. This photolight is also used to study fluid flow, vibration, and high speed rotational and linear motion. Check coupon for GEC-337. Price of Photolight is $751.50*.

*Mfg. suggested retail price.

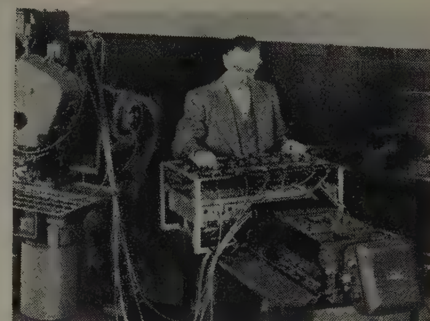
1952 CATALOG

G-E Measuring Equipment

80 pages describing all of General Electric's testing and measuring devices. For free copy check GEC-1016 in coupon at right.



Costly Production Problems Solved with G-E Oscillograph



The United Shoe Machinery Corporation's research division gets the answers to timing and strain design problems by using General Electric PM-10 oscillographs.

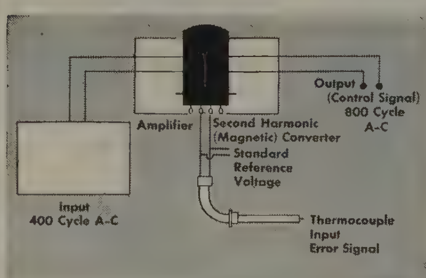
PM-10 USED WITH STRAIN GAGES

A lever and cam system on their new Welt Butting and Tacking Machine, Model B, was breaking and causing high maintenance expense. In order to find the cause of the trouble, a six channel a-c strain gage amplifier was used in conjunction with a PM-10 oscillograph to record the strains while the machine was operating normally. The answers obtained enable USMC engineers to quickly solve this important field service problem.

RECORDS MANY QUANTITIES

Designed to meet the wide field of applications for a twelve-element oscillograph, the Type PM-10 can be used to make simultaneous records of voltage, current, time, pressure, speed, stress, strain, sound, vibration, etc. Viewing while a record is being made is possible. Timing lines can be recorded directly on the film. Prices start at $4000.00 for the complete equipment. For more information check coupon for bulletin GEC-449.

COMPACT SECOND-HARMONIC CONVERTER IS USEFUL IN MANY CONTROL SYSTEMS



A completely static device, the General Electric second-harmonic converter converts small d-c signals, such as a thermocouple output, to an a-c voltage.

Designed mainly for use with 400 cycle excitation, this magnetic amplifier converts low level d-c error signals to an 800 cycle output.

RELIABLE OPERATION

Especially well suited for aircraft and guided missile applications because it is static and hermetically sealed, the converter has a long life even when operated continuously under extreme conditions of acceleration, temperature, pressure, and humidity. For additional information check coupon for bulletin GEC-832 or contact your nearest G-E apparatus office.

SECTION C605-26, GENERAL ELECTRIC
SCHENECTADY 5, N. Y.

Please send me the following bulletins: Indicate:

√ for reference only
X for planning an immediate project

☐ Photolight GEC-337
☐ Oscillograph GEC-449
☐ Second-harmonic Converter GEC-832
☐ 1952 Catalog GEC-1016

NAME..............................

COMPANY..............................

STREET..............................

CITY.................. ZONE...... STATE..........

GENERAL ELECTRIC

(*Continued from page 62A*)

making calibration checks. The electronic cabinet contains a deviation indicator plus a majority of the electronics components of the gauge. Strip widths of 10 to 96 inches can be measured at temperatures of 1,350 to 2,050 degrees Fahrenheit and indicated in less than 1 second after the strip passes under the detector head. Power requirements are 550 volt-amperes, 220/440/550 volts, 3 phase, 60 cycle.

Portable Dynamic Balancing Machine. According to the International Research and Development Corporation, 908 West Third Avenue, Columbus, Ohio, the model *652* Vibratron is a portable, rugged, and simple-to-operate electronic machine for the analysis, evaluation, and correction of vibration. It consists essentially of a vibration pickup, multichannel electronic circuit, and a stroboscopic lamp, and operates on 110-volt 60-cycle current. It can be used in maintenance to discover and correct unbalance in manufacturing equipment, or it can be integrated with a test stand for use as production balancing equipment. By means of a 4-step switch in the amplitude circuit, meter readings can be obtained in full scale from 0.0001 to 0.1 inch peak to peak. Pickup output is 82 millivolts at 0.001-inch deflection at 60 cycles. A detailed folder is available on written request to the manufacturer.

Regulated Power Supplies. The new *400* Series regulated power supplies of the Bristol Engineering Corporation are compact units designed to be combined into multiple output systems with both filament and direct voltages controllable at a central point. Relay control of both filament and direct voltages makes possible many different methods of control, including the useful fail-safe provision whereby failure of any supply can be made to remove voltage from other supplies. Currently available standard models include the *401* with an output of 250–500 volts direct current at 200 milliamperes (650 volts unregulated), and the *402* with an output of 150–325 volts direct current at 200 milliamperes (450 volts unregulated). Further information will be supplied by the Bristol Engineering Corporation, Lincoln Avenue and Pond Street, Bristol, Pa.

TRADE LITERATURE

Attenuators. The Daven Company of Newark, N. J., has announced the availability of its latest brochure on attenuators. A wide variety of controls is shown, including radio-frequency attenuators, special units for precision measuring equipment, tone compensating attenuators, stereophonic controls, and "*T*", balanced "*H*", ladder, and potentiometer-type audio attenuators. Each unit is discussed separately with photographs of the unit, complete descriptions, charts, and dia-

(*Continued on page 68A*)

(*Continued from page 64A*)

grams. Write to the Daven Company, Department GI, 191 Central Avenue, Newark 2, N. J., for a copy of this brochure.

Electronic Transformer Applications. The latest catalogue of the United Transformer Company, just released, lists over 600 stock items covering the entire scope of electronic transformer applications. This catalogue is fully indexed, giving complete technical descriptions of all items. In addition, a center insert gives circuit details for high-fidelity amplifier equipment. A number of pages are devoted to High Q Filter Coils and complete Audio Filters. For a free copy of this catalogue, write to the United Transformer Company, 150 Varick Street, New York 13, N. Y.

Product and Engineering Catalogue. The R and IE Equipment Division, I-T-E Circuit Breaker Company, Greensburg, Pa., is distributing a loose-leaf Product and Engineering Catalogue. Consisting of 406 pages, the new R and IE Catalogue contains illustrations, detailed drawings, and dimensions covering the full line of R and IE switches, accessories, and testing devices. Descriptions of features and applications, plus price listings, are included in the catalogue.

Allied Radio Catalogue. Allied Radio Corporation has announced the release of their 1953 general catalogue, containing 236 pages listing 18,000 items. Special emphasis has been placed on equipment for industrial maintenance, research and production requirements. There are detailed listings of standard and special-purpose electronic tubes, test instruments, voltage stabilizers, transformers, resistors, capacitors, printed circuit components, transistors, relays, switches, and a wide variety of other electronic equipment and components. This 1953 buying guide may be obtained without charge upon request to Allied Radio Corporation, 833 West Jackson Boulevard, Chicago, Ill.

Watt-hour Meter Design and Manufacture. A new, 16-millimeter sound-color motion picture describing the radical design developments, manufacturing techniques, and the quality control procedures which permit factory certification of General Electric I-50 watt-hour meters has been announced by the company's Meter and Instrument Department. Titled "Accent on Accuracy," the film demonstrates the principles, history, and maintenance problems of the various watt-hour meters. Included in the motion picture are animated sequences which show the operation of watt-hour meters, how development has kept pace with load growth, and how the I-50 floating disk operates.

(*Continued on page 72A*)

(*Continued from page 68A*)

Prints of the film, running time 25 minutes, are available for loan at General Electric district apparatus offices.

Metallized-Paper Capacitors. The higher temperatures and applications of Aerolene-impregnated metallized-paper capacitors are presented in a bulletin entitled "High Temperature Metallized-Paper Capacitors" obtainable on request from Aerovox Corporation, New Bedford, Mass. The bulletin lists the standard numbers of the modified plastic tubular type *P92ZN*, the "bathtubs" type *P30ZN*, and the metal-cased tubulars with vitrified ceramic terminal and seals type *P123ZNG*. Drawings and dimensions are included. There is also basic information on performance characteristics.

Hydraulic Cylinders. A 28-page 2-color bulletin Number *701* on Lindberg Hydraulic Cylinders has been released. This bulletin describes the complete line of hydraulic cylinders manufactured by the company. Diagrams, illustrations, and charts explain the different mounting types and capacities of the cylinders up to 1,500 pounds per square inch. Copies are obtainable from Lindberg Engineering Company, 2443 West Hubbard Street, Chicago 12, Ill.

Orthicon Television Camera Chain. A 20-page booklet on the Du Mont universal image orthicon television camera chain Model *TA-124-E* is available to television station personnel, prospective television broadcasters, and others in the television and radio industry from the Television Transmitter Division, Allen B. Du Mont Laboratories, Inc., 1500 Main Avenue, Clifton, N. J. The booklet, illustrated with photographs and drawings of the camera and its associated equipment, explains how a single triple-duty Du Mont chain can be used in studios, in the field, and for film pickup.

Trolley Power Distribution. The Feedrail Corporation, 125 Barclay Street, New York, N. Y., has released Catalogue *30* describing the Heavy Duty Feedrail Trolley Busway Systems. These systems provide a movable source of power for long runs of heavy moving electric loads. Power take-off trolleys run in a steel housing that safely encloses the current-carrying bus bars. Other detailed information is given in the catalogue.

Zeolite Water Softeners. Troubles caused by the utilization of hard water and the multiple economies effected by curing them are discussed in a comprehensive 16-page bulletin, Number *2386*, issued by The Permutit Company, 330 West 42d Street, New York, N. Y. The bulletin lists several industries in which steam and water are of importance. It explains the three basic types of ion-exchange equipment and shows how these units can be profitably utilized.

You Need HIGH PRESSURE

KEARNEY (*Field-Proved*)

FOR BETTER CONSTRUCTION and MAINTENANCE

Always Specify

KEARNEY PRODUCTS

SWITCHING EQUIPMENT

Open and Enclosed Fuse Cutouts
Reclosing Type Fuse Cutouts
Secondary Fuse Cutouts
Primary and Secondary Fuse Links
Oil Circuit Reclosers
Sectionalizer
Hook Operated Disconnect Switches
Group Operated Disconnect Switches
Lightning Arresters
Street Lighting Multiple Relay

SOLDERLESS CONNECTORS

Squeezon Compression Connectors
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Service Connectors
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Power Connectors

POLE LINE EQUIPMENT

Anchors
Guy Guards
Guy Wire Clips
Dead End Service Clamps
Ground Rod Clamps
Capacitors
Hot Line Clamps
Telephone Accessories
Grounding Sets
Rope

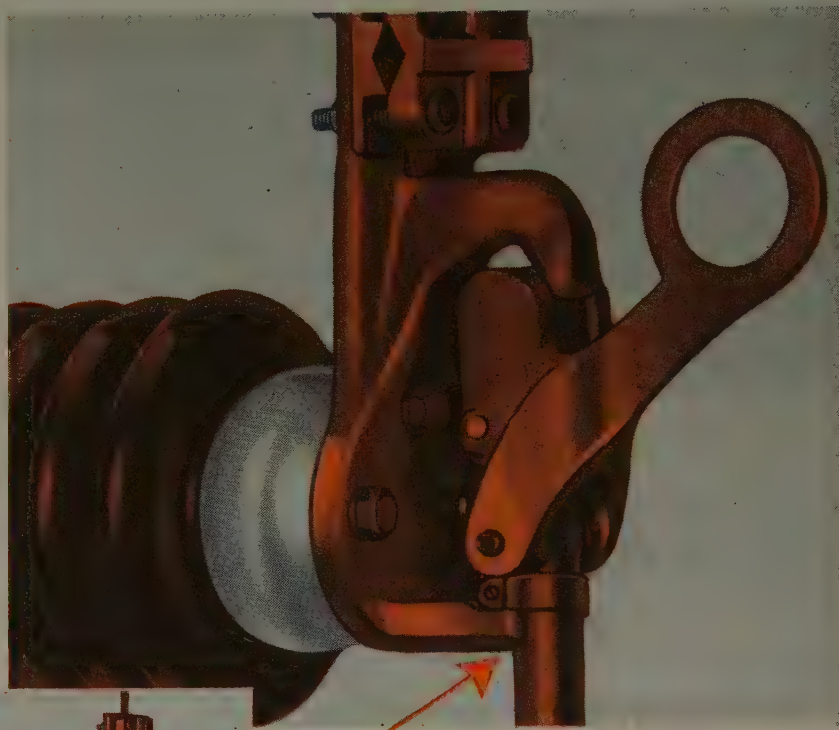
HI LINE TOOLS

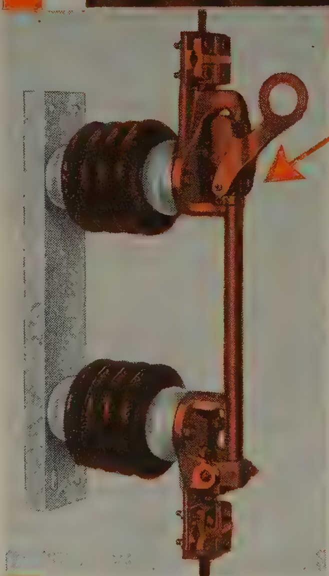
A complete line of tools and equipment for repair and maintenance of energized high voltage power lines.

Write for more information and prices to Dept. W

JAMES R. KEARNEY CORPORATION ST. LOUIS, MO. GUELPH, ONT.

The Mark of Quality Products





The Ultra High Pressure Disconnect Switch is manufactured in 6 ratings: 7,500 to 69,000 volts; 400-600 amps.

Kearney Ultra High Pressure Disconnect Switches provide contact pressures 20 times higher than ordinary hook operated disconnects. This high pressure plus silver contact inserts cut temperature rise in half!

Low operating temperature means less oxidation, reduced maintenance costs. Wide open "V" block contacts prevent galling or binding of blade.

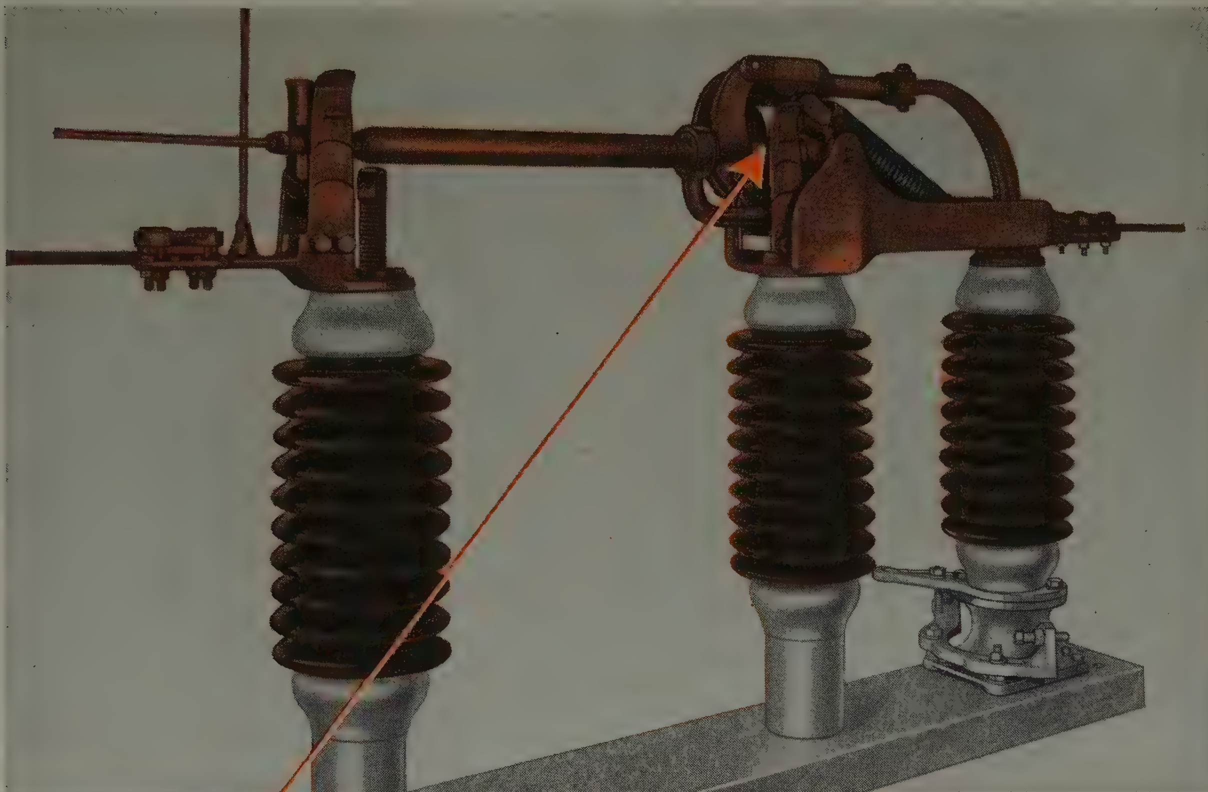
High pressure is supplied by toggle action . . . there are no springs to fatigue and wear out. Switch life is increased many times by this feature. Separate arcing areas protect main contacts against pitting. First part of the opening motion breaks the main contacts before roller snaps clear of the latch.

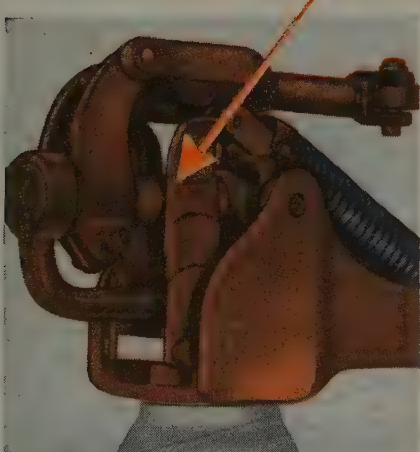
KEARNEY

JAMES R. KEARNEY CORPORATION

CONTACTS for To-day's Load

SWITCHES Carry Full Rated Current at Lower Operating Temperatures.





Kearney rotating insulator group operated switches are available in ratings to 69 KV, 400-600 amps., vertical or side break.

Look at the heavy beryllium copper contacts at each end of the blade on this ***Kearney Group Operated, Vertical Break Switch.*** Both with silver top lay, they provide a positive, high pressure current path completely through the switch without using any part of the hinge mechanism as a transfer point. This means cooler operating temperatures under full-rated load . . . and less trouble-making oxidation as a result.

Two Oilite bearings allow free blade rotation for full wiping action while maintaining perfect alignment with both contacts. Every critical action of the switch and operating mechanism is made adjustable to synchronize phase sections and compensate for shifts in mounting structure or play in interphase rod travel

PRODUCTS

4236 CLAYTON AVE., ST. LOUIS, MO. • CANADIAN PLANT GUELPH, ONTARIO

The Ohmite line of tab-terminal, ferrule-terminal, axial-terminal, and flat type resistors that meet JAN-R-26A, Characteristics "G" and "J."

OHMITE JAN TYPE WIRE-WOUND *Resistors*

Ohmite tab-terminal and ferrule-terminal type resistors that meet JAN-R-26A, Characteristic "F."

STYLES AND SIZES

TAB-TERMINAL TYPE Characteristics G, J, and F

Style	Over-all length	Diameter	*Watts
RW-29	1-3/4"	1/2"	8
RW-30	1"	19/32"	8
RW-31	1-1/2"	19/32"	10
RW-32	2"	19/32"	12
RW-33	3"	19/32"	18
RW-34	3"	29/32"	30
RW-35	4"	29/32"	38
RW-36	4"	1-5/16"	60
RW-37	6"	1-5/16"	78
RW-38	8"	1-5/16"	110
RW-39	12"	1-5/16"	166

TAB-TERMINAL TYPE with terminal hole to clear No. 8 screw Characteristics G, J, and F

Style	Over-all length	Diameter	*Watts
RW-40	3"	29/32"	24
RW-41	4"	29/32"	32
RW-42	4"	1-5/16"	49
RW-43	6"	1-5/16"	74
RW-44	8"	1-5/16"	100
RW-45	12"	1-5/16"	160
RW-46	10-1/2"	1-5/16"	135
RW-47	10-1/2"	1-9/16"	145

FERRULE-TERMINAL TYPE Characteristics G, J, and F

Style	Over-all length	Diameter	*Watts
RW-10	11-7/16"	1-5/16"	140
RW-11	9-5/8"	1-5/16"	116
RW-12	7-7/16"	1-5/16"	86
RW-13	5-1/8"	1-1/16"	50
RW-14	4-7/16"	1-1/16"	40
RW-15	2-15/16"	3/4"	20
RW-16	2-3/8"	3/4"	14

FLAT TAB-TERMINAL TYPE (Stack Mounting) Characteristics G and J

Style	Over-all length	Width of Core	Thickness of Core	†Watts
RW-20	2-1/2"	1-3/16"	1/4"	15
RW-21	3-1/4"	1-3/16"	1/4"	22
RW-22	4-3/4"	1-3/16"	1/4"	37
RW-23	6"	1-3/16"	1/4"	47
RW-24	7-1/4"	1-3/16"	1/4"	63

AXIAL-TERMINAL TYPE Characteristics G and J

Style	Length of Core**	Diameter	†Watts
RW-55	1-3/8"	5/8"	5
RW-56	2"	5/8"	10

**2-1/2" wire leads

*Watts free air JAN Characteristic "F" or "G"

†Watts free air JAN Characteristic "G"

...MEET REQUIREMENTS OF JOINT ARMY-NAVY SPECIFICATION JAN-R-26A

(Amendment 3)

Ohmite offers an unusually complete line of resistors that meet the most rigid requirements (characteristics "G," "J," and "F") of Joint Army-Navy Specification JAN-R-26A. To meet these requirements, resistors must pass severe moisture resistance and thermal shock tests. They are required to withstand strenuous vibration applied for five continuous hours, and satisfy the requirements of many other tests.

Of the 38 different resistor styles listed in JAN-R-26A, Ohmite offers 33 styles that meet these specifications, in a complete range of resistance values.

OHMITE MANUFACTURING COMPANY
4803 Flournoy Street, Chicago 44, Illinois

Be Right with...

OHMITE®

RHEOSTATS • RESISTORS • TAP SWITCHES

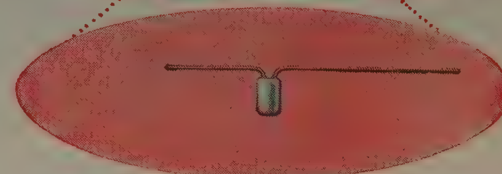

Making only the Best...

INTERNATIONAL RECTIFIER CORPORATION

EL SEGUNDO CALIFORNIA

Selenium Rectifiers

SMALLEST



SELENIUM DIODES

DIAMETER: From 1/8″ to 13/32″
LENGTH: From 1/4″ to 1/2″
RMS applied voltage:
From 26 volts to 104 volts
RMS input current:
max. 500 microamperes
DC output voltage:
From 20 volts to 80 volts
DC output current: avg. from 200 microamperes to 5 milliamperes
Reverse Leakage at 10 volts RMS:
0.6 microamperes to 2.4 microamperes
Potted in thermosetting compound
Temperature Range:
From -60° C to 100° C
Available in 1, 2, 3 and 4 cell Diodes

Send for Bulletin SD-1

TO

LARGEST

POWER RECTIFIERS

CELL SIZES: From 1″x 1″ to 6¼″x 7¼″
CURRENT RATINGS, per cell:
0.125 amperes to 7 amperes
VOLTAGE RATINGS, inverse per cell:
22 volts rms to 40 volts rms
Efficiency to 87%. Power factor 95%
Suitable for oil immersion.
Ratings to 250 KW. *Send for Bulletin C-349*

INTERNATIONAL RECTIFIER CORPORATION

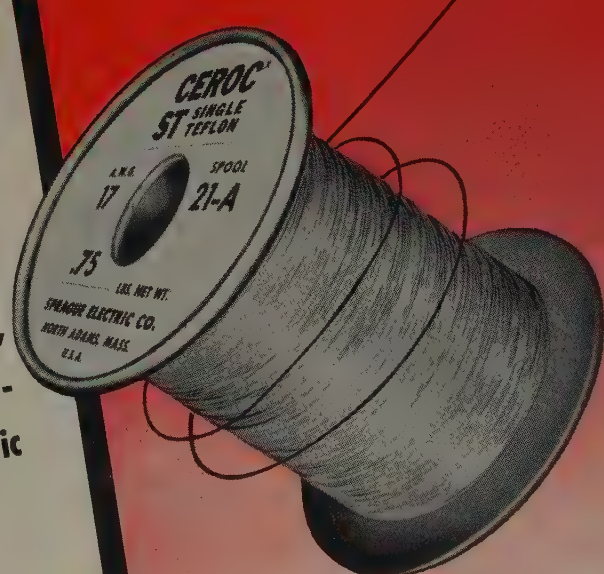
General Offices: 1521 E. Grand Ave., El Segundo, Calif. • Phone: El Segundo 1890
Chicago Branch Office: 205 West Wacker Drive • Phone: Franklin 2-3889
New York Branch Office: 12 West 32nd Street, N. Y. 1 • Phone: Chickering 4-0017

SPRAGUE® LEADS THE WAY WITH RELIABLE HIGH TEMPERATURE (250°C) MAGNET WIRE

250°C
200°C
150°C
105°C

Ceroc ST®

Magnet Wire, with its combination of ceramic base insulation and a single Teflon overlay, eliminates most problems met with all-plastic insulations.

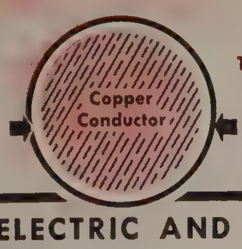


Designers of miniaturized transformers, motors, coils, solenoids, etc., are finding that Ceroc ST Magnet Wire leads the field in *tough* applications. Not only does Ceroc ST have superior abrasion resistance to commercial all-tetrafluoroethylene insulated wire, but it also has better cross-over characteristics, and a higher breakdown voltage. The Teflon overlay bonds more securely to the ceramic base insulation than is the case with Teflon bonded directly to copper. And with its years of experience in quality control, the Sprague Electric Company delivers to you a product of uniformly high quality.

Not only may Ceroc ST wire be operated *continuously* at temperatures up to 250°C, but it has been successfully used in short-time military applications at temperatures as high as 350°C. Sprague's Application Engineering Dept. is ready to assist you in working out any problems you may have on the proper use of high temperature magnet wire.

For details on Ceroc ST wire, write for Engineering Bulletin No. 404. Where design requirements necessitate a heavier Teflon coating, investigate Ceroc T wire, with its double Teflon overlay on ceramic base insulation. It's described in Engineering Bulletin No. 402-F. Copies available without obligation on letterhead request to the Application Engineering Dept., Sprague Electric Co., 321 Marshall St., North Adams, Massachusetts.

ENLARGED CROSS-SECTION OF CEROC ST



SPRAGUE . . . PIONEERS IN ELECTRIC AND ELECTRONIC DEVELOPMENT

6 BIG REASONS WHY VICTOR PURIFIED PORCELAIN SWITCH and BUS INSULATORS ARE BETTER!

VICTOR NO. 742 (NEMA TR-No. 7).
For complete engineering data on all Victor Switch and Bus Insulators, send for Bulletin No. 5.

1. Improved thermal resistance. Purified Porcelain, pure porcelain all the way through, expands and contracts more uniformly during sudden temperature changes.

2. Unmatched porcelain hardness and density, resulting in rock-like strength.

3. Higher average puncture values.

4. Better tension, torsion, cantilever and impact values.

5. Smoother, harder glaze with unequalled self-cleaning characteristics.

6. Finest insulator porcelain ever made—uniformity of quality never before achieved!

Specify
VICTOR
SWITCH and BUS INSULATORS

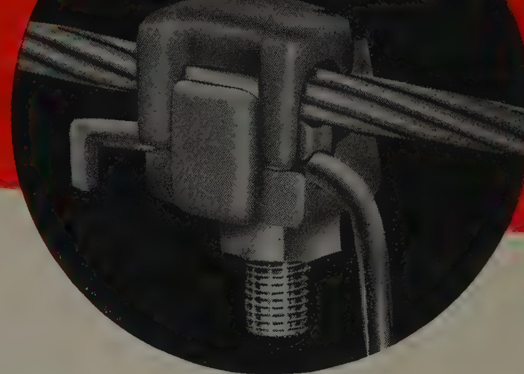
VICTOR INSULATORS, INC., VICTOR, N.Y.

GREATER COPPER DISTRIBUTION SYSTEM

Security

WITH BRONZE ONE PIECE K-90 AND K-900 CONNECTORS

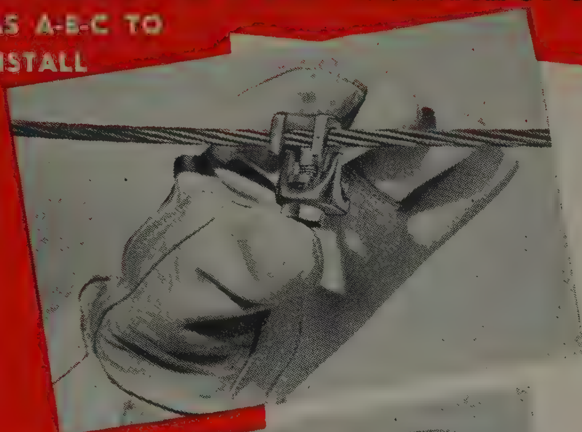
COMPLETE
TROUBLE FREE
POSITIVE CONNECTION



EASY AS A-B-C TO INSTALL

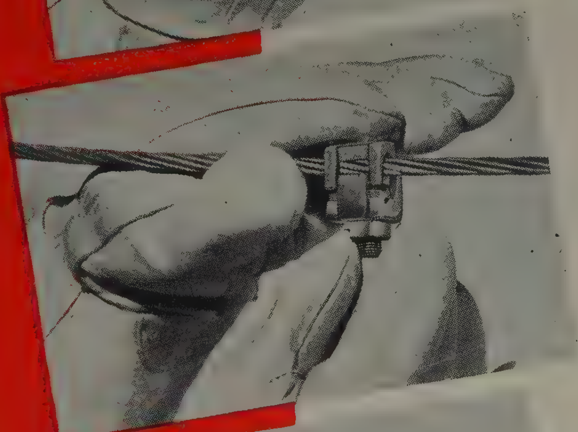
A

HANG ON MAIN



B

SPIN NUT TO PARTIALLY CLOSE



C

INSERT TAP AND TIGHTEN

For

- **GREATER STRENGTH:** *Compresses Conductor sealing out high resistance oxide formation on contact areas.*
- **GREATER EFFICIENCY:** *Retains high pressure contact during vibration and temperature changes.*
- **GREATER DEPENDABILITY:** *Surpasses Mercurous Nitrate Specifications ABW 124-1*, insures against seasonal and stress corrosion cracking failure.*
- **GREATER ECONOMY:** *Lower installation cost, five sizes for connections up to 500 MCM.*
- **GREATER FLEXIBILITY:** *Taps, splices and dead ends easily completed with gloves or hot line tools.*

**Identical to ASTM B-154-45 Mercurous Nitrate Specifications except ABW-124-1 specifies stress components which is a more severe test.*

WRITE TODAY FOR BULLETIN K-150 on K-90 and K-900 DISTRIBUTION CONNECTORS

OUR PRODUCTS ARE QUALITY CONTROLLED FROM INGOT TO FINISHED PRODUCT

CONSULT ONE OF OUR NEAREST EIGHTEEN REPRESENTATIVES OR CONTACT OUR MAIN OFFICE

ABW

Anderson Brass Works, Inc.

Aluminum POST OFFICE DRAWER 2151 *Bronze*

BIRMINGHAM, 1, ALABAMA

SUBSTATION — TRANSMISSION — DISTRIBUTION

Power Connectors, Clamps, Fittings and Accessories

SWIFT, SURE FREQUENCY COMPARISON

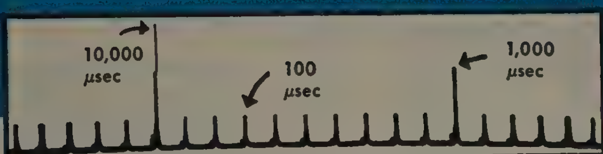


FIG. 1. Timing Comb, -hp- Model 100D

NEW (hp) SECONDARY

FREQUENCY STANDARDS

MODELS 100C AND 100D

- Sine or rectangular waves
- 100 μsec time markers
- Built-in oscilloscope
- Stability 1/1,000,000
- Low output impedance
- New, improved circuits
- Audio, supersonic, rf measurements

SPECIFICATIONS

-hp- 100D Secondary Frequency Standard

Accuracy: About 2 parts per million per week, normal room temperature.

Stability: About 1 part per million over short intervals.

Output: Controlled frequencies: 100 kc, 10 kc, 1 kc, 100 cps, 10 cps. Sine or rectangular waves; marker pips. Internal impedance approx. 200 ohms.

Wave Shape: Sine wave: less than 4% distortion into 5,000 ohms or higher load.

Marker Pips: 10,000, 1,000 and 100 μsec intervals.

Oscilloscope: Integral with circuit. Establishes 10:1 Lissajous figures to show division ratio. May be used independently of standard.

Price: $600.00.

-hp- 100C Secondary Frequency Standard

Accuracy: Within ± .001% normal room temperature.

Output: Controlled frequencies of 100 kc, 10 kc, 1 kc, and 100 cps. Internal impedance approx. 200 ohms.

Wave Shape: Sinusoidal only. 4% distortion into 5,000 ohm load.

Power Supply: (100C and 100D) 115/230 v ± 10%, 50/60 cps, regulated to minimize line voltage fluctuations. Power drawn approx. 150 watts.

Mounting: (100C and 100D) Cabinet or relay rack. Panel 19" x 10½". 12" deep.

Price: $450.00.

Data Subject to Change Without Notice
Prices f.o.b. factory

The new *-hp-* 100C and 100D Secondary Frequency Standards incorporate all the features of the time-tested *-hp-* models 100A and 100B, plus important new advantages including rectangular wave output, timing pips, and an internal oscilloscope for convenient frequency comparison. The *-hp-* 100D may be conveniently standardized against station WWV with a minimum of external equipment, and thus provide most of the advantages of an expensive primary standard.

Crystal Controlled Frequencies

The new *-hp-* Models 100D and 100C employ a crystal-controlled oscillator and divider circuits offering a new high in stability and simplicity of operation. Standard frequencies are available through a panel selector switch, and may be employed simultaneously. Internal impedance is low (about 200 ohms), so that standard frequencies can be delivered at some distance from the instrument.

The *-hp-* 100D Secondary Frequency Standard offers sine waves at 5 frequencies and rectangular waves at 4 frequencies, plus a built-in oscilloscope. The instrument also provides a timing comb with markers 100, 1,000 and 10,000 microsecond intervals. Rectangular wave output has a rise time of approximately 5 microseconds. Accuracy is 2 parts per million.

5 v. at all Frequencies

The more moderately priced *-hp-* 100C Standard offers sinusoidal frequencies at 4 crystal-controlled frequencies and, like the *-hp-* 100D, provides 5 volts of output at all frequencies. Accuracy .001%.

Both models operate from a 115 v. ac power supply, and power is regulated to minimize power line voltage fluctuations.

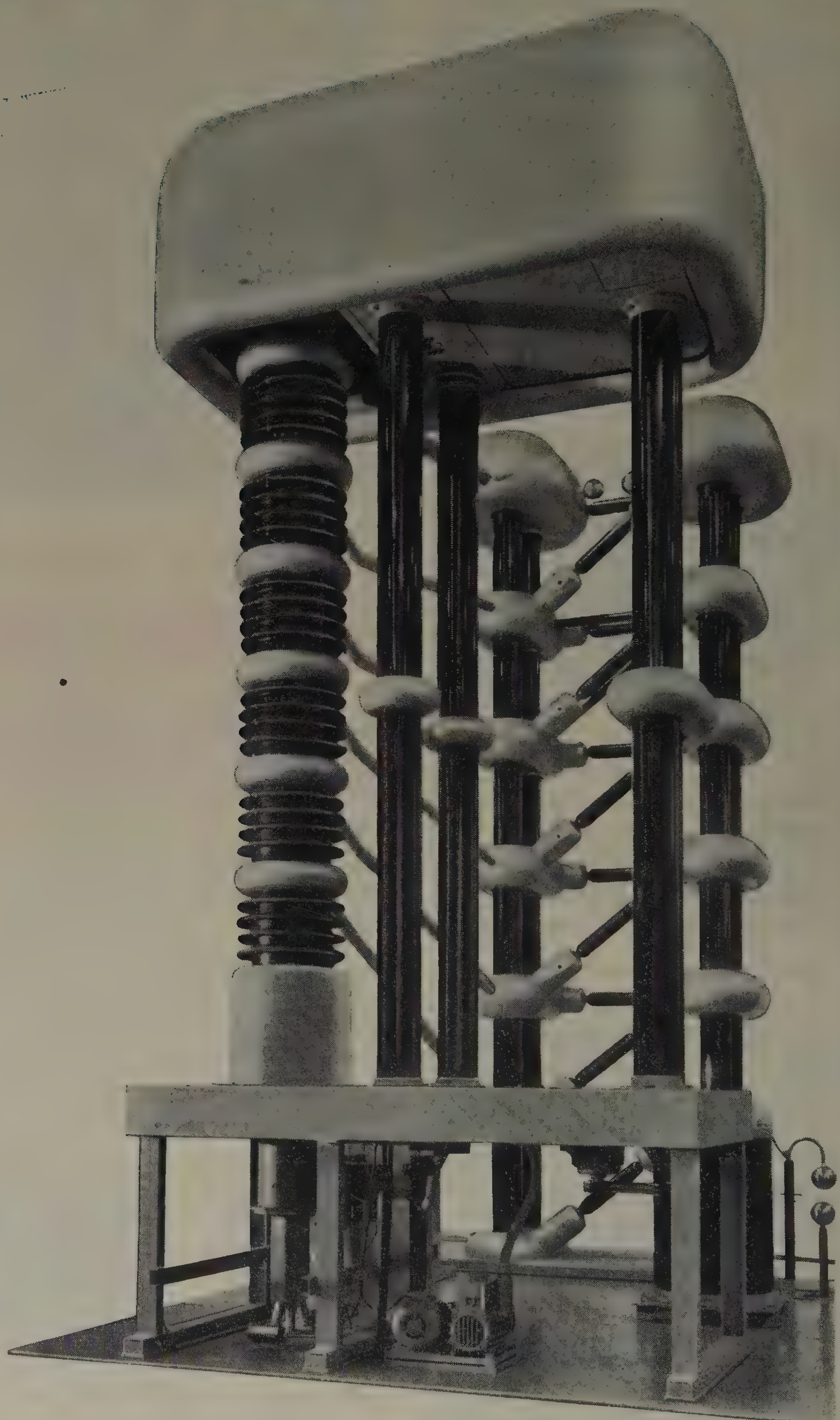
Get full details . . . see your -hp- representative or write direct . . . today!

HEWLETT-PACKARD CO.
1977E Page Mill Road • Palo Alto, Calif.
Export: FRAZAR & HANSEN, LTD.
301 Clay Street, San Francisco, Calif., U. S. A.
Offices: New York, N. Y.; Los Angeles, Calif.

(hp) Instruments for Complete Coverage

HIGH VOLTAGE TESTING

For more than 40 years we are manufacturing high voltage testing equipment



Testing Transformers
Surge Generators
Rectifiers for High Voltages
Neutron - Generators
Potentiometer for a.c., d.c. and Impulse - Voltages
Cathode - Ray - Oscillographs

Neutron-Generator 1200 kV completely fitted with ion-source, acceleration tube, targets, pump and control desk.

Such generators can be supplied for voltages up to 2.000.000 volts.

Telegrams: Micarta Basel

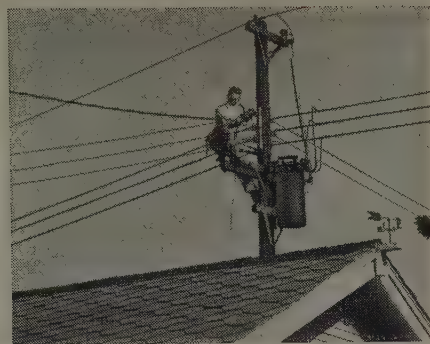
27 A

EMILE HAEFELY & CO. LTD. BASEL SWITZERLAND

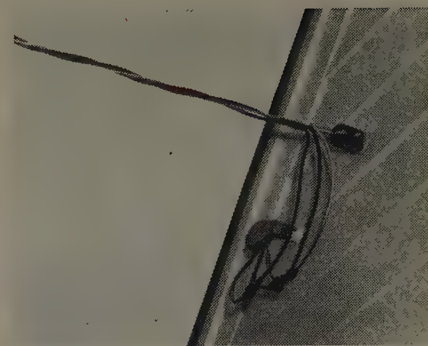
THERE'S A DIFFERENCE

when you specify aluminum conductor

IMMEDIATE SAVINGS—Aluminum conductor gives you *immediate* savings. Initial cost far less than copper. Easier handling because of aluminum's lighter weight.



INSTALLATION SAVINGS—Aluminum's lightness helps insure faster installations. Linemen find it easier to string, handle, move around. Saves time and money.

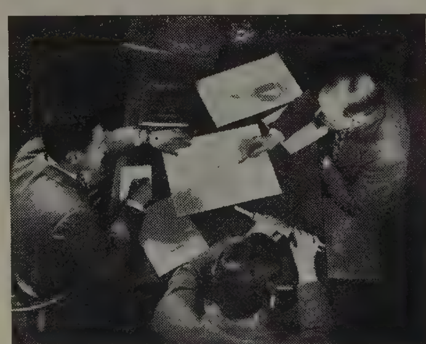


MAINTENANCE SAVINGS—Aluminum's lightness assures lower tensions on house, pole. Minimum maintenance required on lines and services. Potential *total* savings with aluminum conductor—up to 25%.

THERE'S A BIG DIFFERENCE

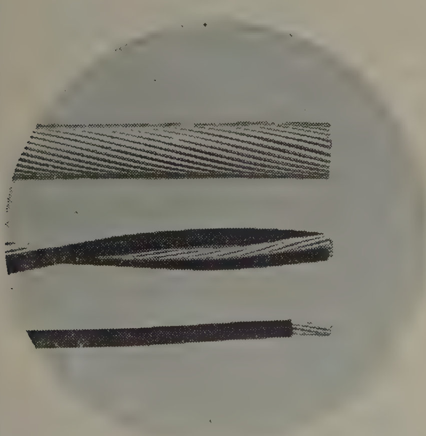
when you specify Kaiser Aluminum conductor

FIELD SERVICE—Experienced Kaiser Aluminum field men work hand in hand with crews on stringing operations, often devise money-saving techniques. They continually check installation schedules—one big reason why Kaiser Aluminum's record for *on-time delivery* is unsurpassed!



ENGINEERING AND LABORATORY SERVICE—Kaiser Aluminum engineers suggest methods to improve quality, cut costs. They make full use of top-notch Kaiser Aluminum laboratories, call in specialists for organizational meetings, furnish sag and tension charts.

CONVENIENT DISTRIBUTOR SERVICE—Kaiser Aluminum conductor distributor offices are located nearby you, wherever you are. They stock a wide range of Kaiser Aluminum conductor—offer quick service and helpful technical assistance.



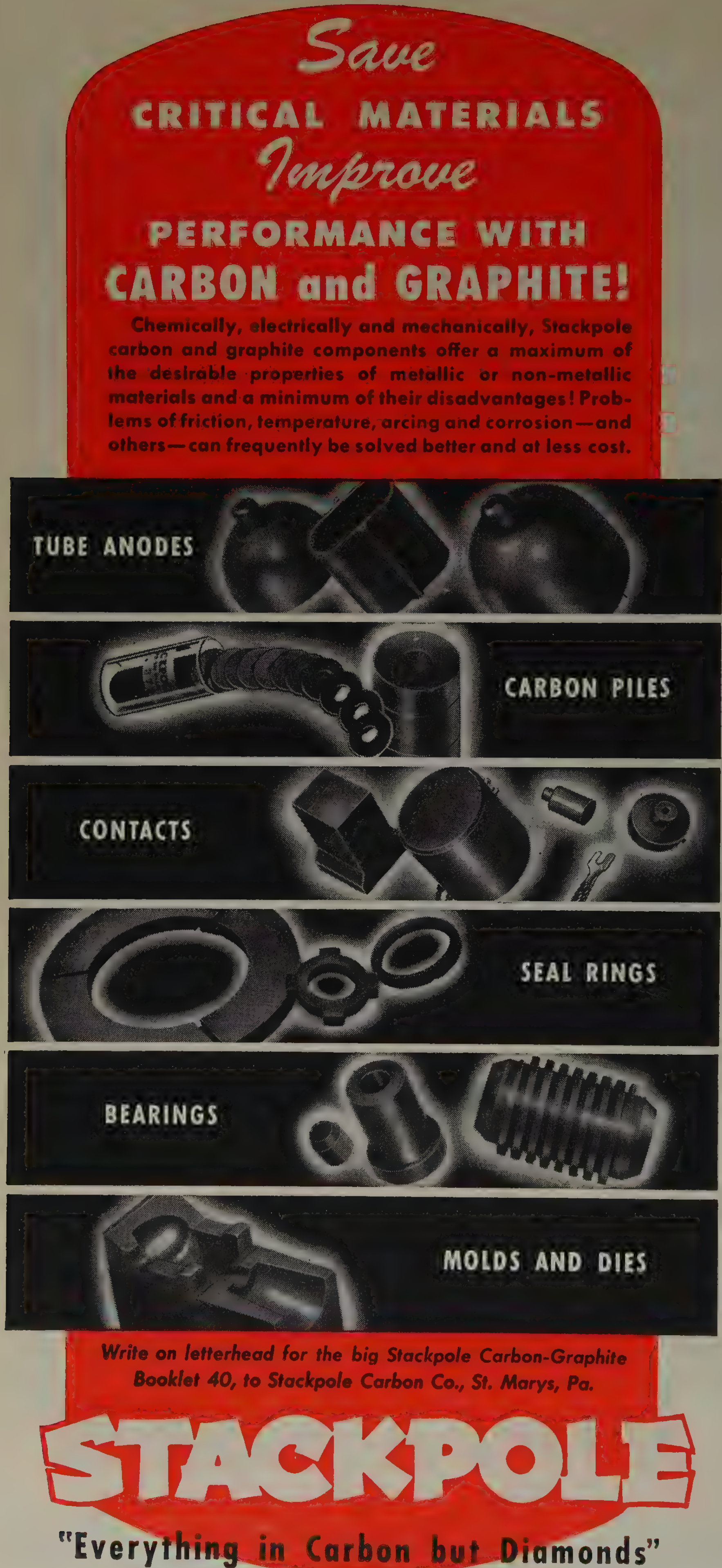
THIS COMPLETE SERVICE is available to you at no obligation when you specify Kaiser Aluminum conductor. *Act now!* A letter or telephone call is all that's required. Also request free pamphlet giving complete engineering data on new Kaiser Aluminum covered conductor—both weatherproof line wire and self-supporting Triplex cable for service drops and secondary distribution lines.

Contact any Kaiser Aluminum office in principal cities, or one of our many distributors. Kaiser Aluminum & Chemical Sales, Inc., Oakland 12, California.

Kaiser Aluminum

Setting the pace . . . in growth, quality and service

NEOPRENE AND POLYETHYLENE COVERED CONDUCTOR, SOLID AND STRANDED • SELF-SUPPORTING TRIPLEX CABLE • ACSR • ALL ALUMINUM CONDUCTOR



WANTED

Back copies of TRANSACTIONS of The American Institute of Electrical Engineers, Volume 69, 1950, Parts I and II.

Please mail (parcel post) to American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y., printing your name and address upon the mailing wrapper.

Five dollars for both parts, plus postage, will be paid for copies returned.

LIGHTNING REFERENCE BIBLIOGRAPHY 1936-1949

Prepared by the AIEE Lightning and Insulator Subcommittee, this bibliography, S-37, contains 754 separate references on lightning and related topics published from January 1, 1936, to December 31, 1949, in most of the better known English, French, and German journals on electrical engineering or physics.

For easy reference, there is a Subject Section, subdivided into 18 classifications, and an Author Section, which contains a list of about 550 authors. Price: $0.70 ($0.35 to AIEE members).

Available from the Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York, N. Y.

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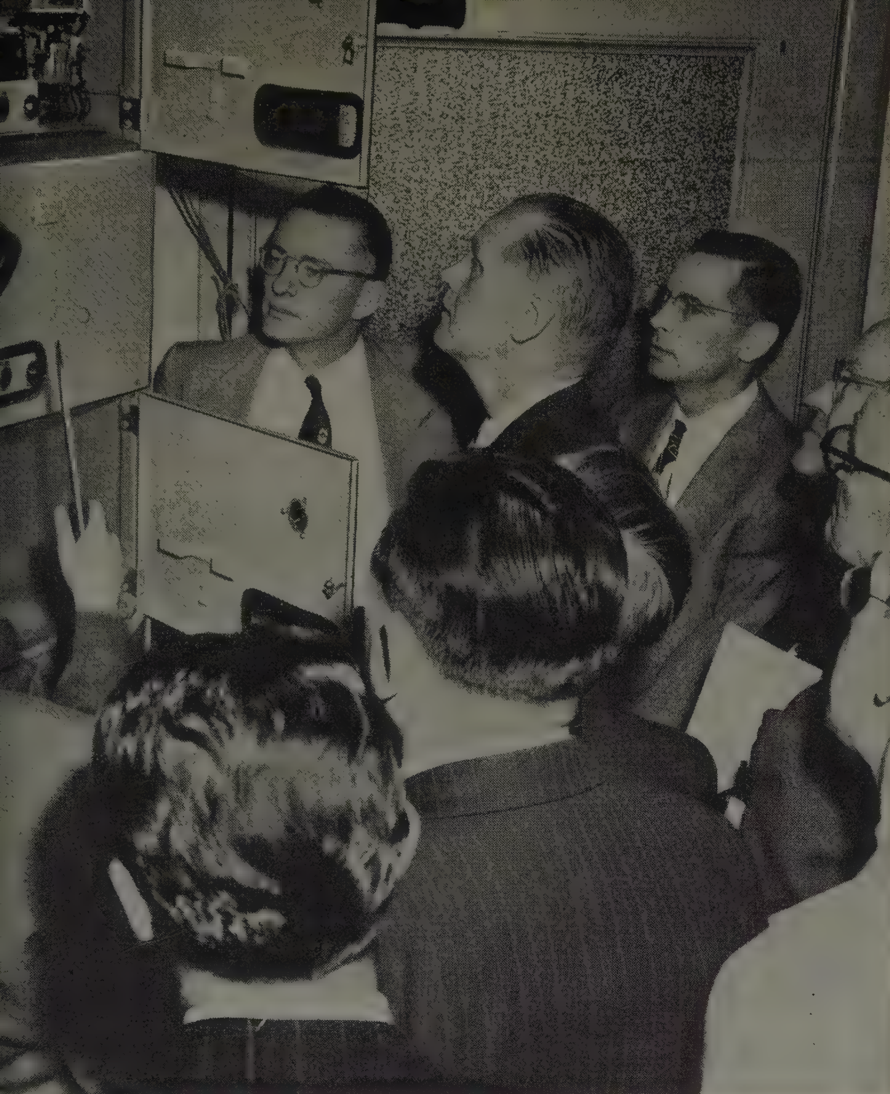
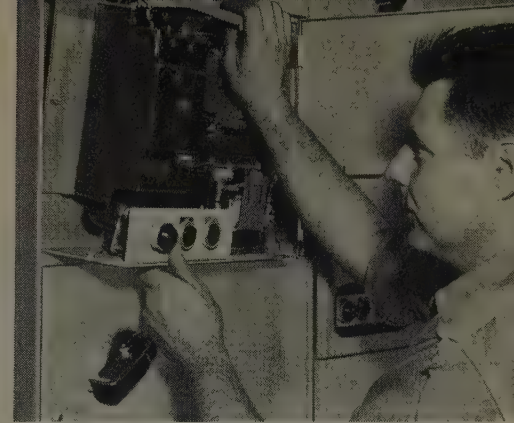
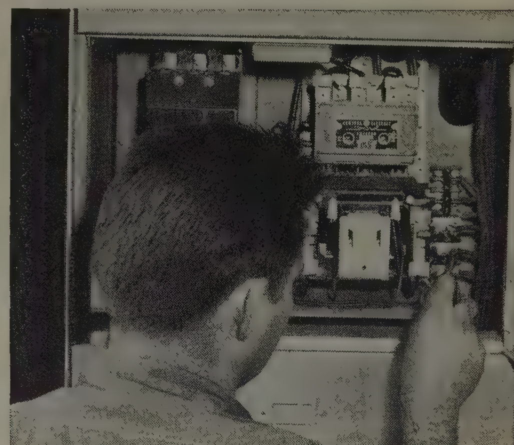
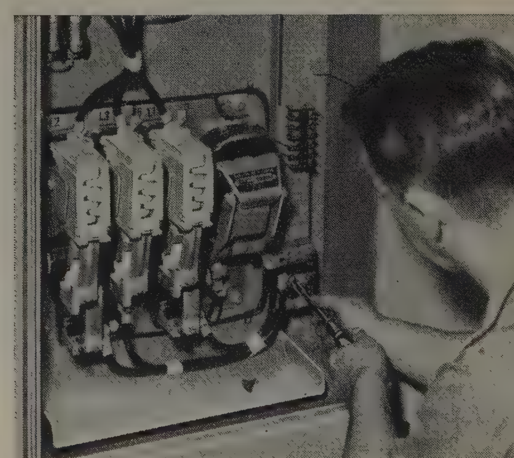




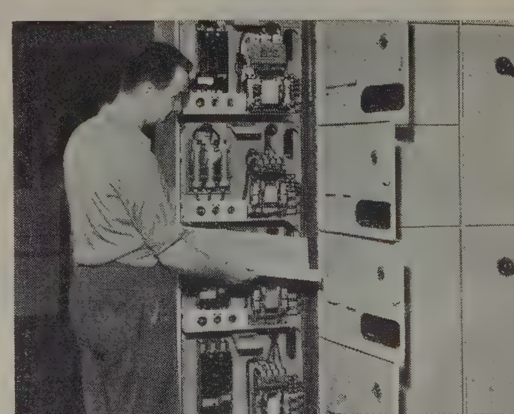
EASY TO INSTALL AND INSPECT. Interchangeable units; main bus completely accessible; incoming line connections are easily made.



EASY TO WIRE. Four-inch wiring trough; components accessible from all sides; front-connected starters; doors swing more than 90°.



EASY TO SERVICE. Units are easily disconnected from bus and locked in test position (above). Barriers between units are easily removed to facilitate wiring (below).



FORD MOTOR COMPANY OFFICIALS INSPECT THE INTERCHANGEABLE UNITS OF THE . . .

New G-E Motor Control Center

Since January, over 10,000 men from production and management of leading industries (see above) have taken a thorough look at the latest equipment for the centralized control of a-c motors up to 200 hp. Their reports indicate enthusiastic approval of what they saw. Here's why:

VERSATILE. Because units are easily interchangeable without waste space, a variety of arrangements can be made. For example—two Size 1 or 2 starter units require the same space as a Size 1, 2, or 3 reversing starter.

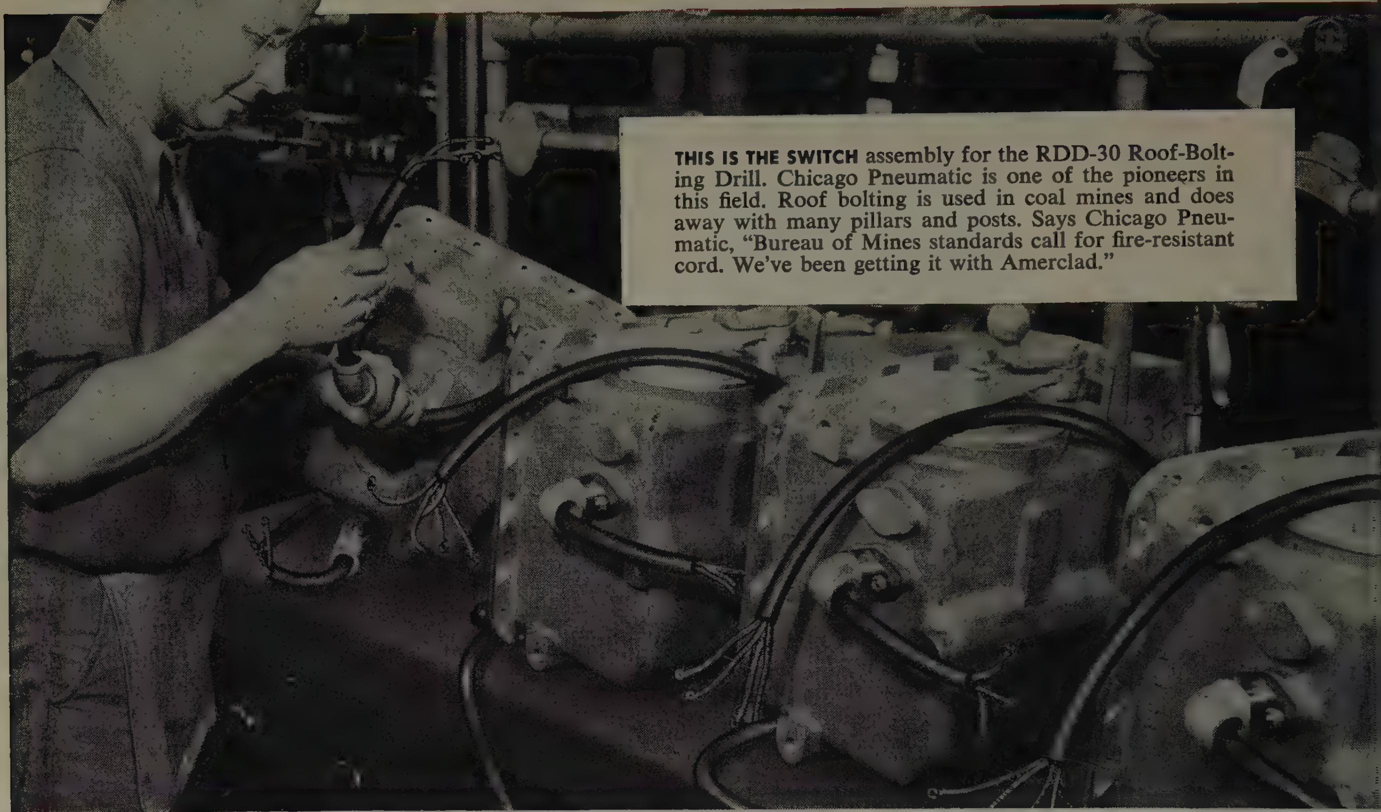
ACCESSIBLE. A four-inch continuous wiring trough provides ample wiring space. Components are mounted on an easy-to-handle frame and accessible from all sides when lifted from cabinet. Starters are front-connected. Master terminal boards can be swung out of compartment for extra working space around conduit.

PROTECTED. Will withstand 25,000 amperes RMS short-circuit current, substantiated by certified Laboratory tests.

For more information on this new G-E motor control center, contact your nearest G-E apparatus sales office or write for Bulletin GEA-4979A today. *General Electric Company, Schenectady 5, N. Y.* 730-42

GENERAL ELECTRIC

HERE'S ANOTHER PRODUCT USING AMERCLAD CORDS . . .



THIS IS THE SWITCH assembly for the RDD-30 Roof-Bolting Drill. Chicago Pneumatic is one of the pioneers in this field. Roof bolting is used in coal mines and does away with many pillars and posts. Says Chicago Pneumatic, "Bureau of Mines standards call for fire-resistant cord. We've been getting it with Amerclad."

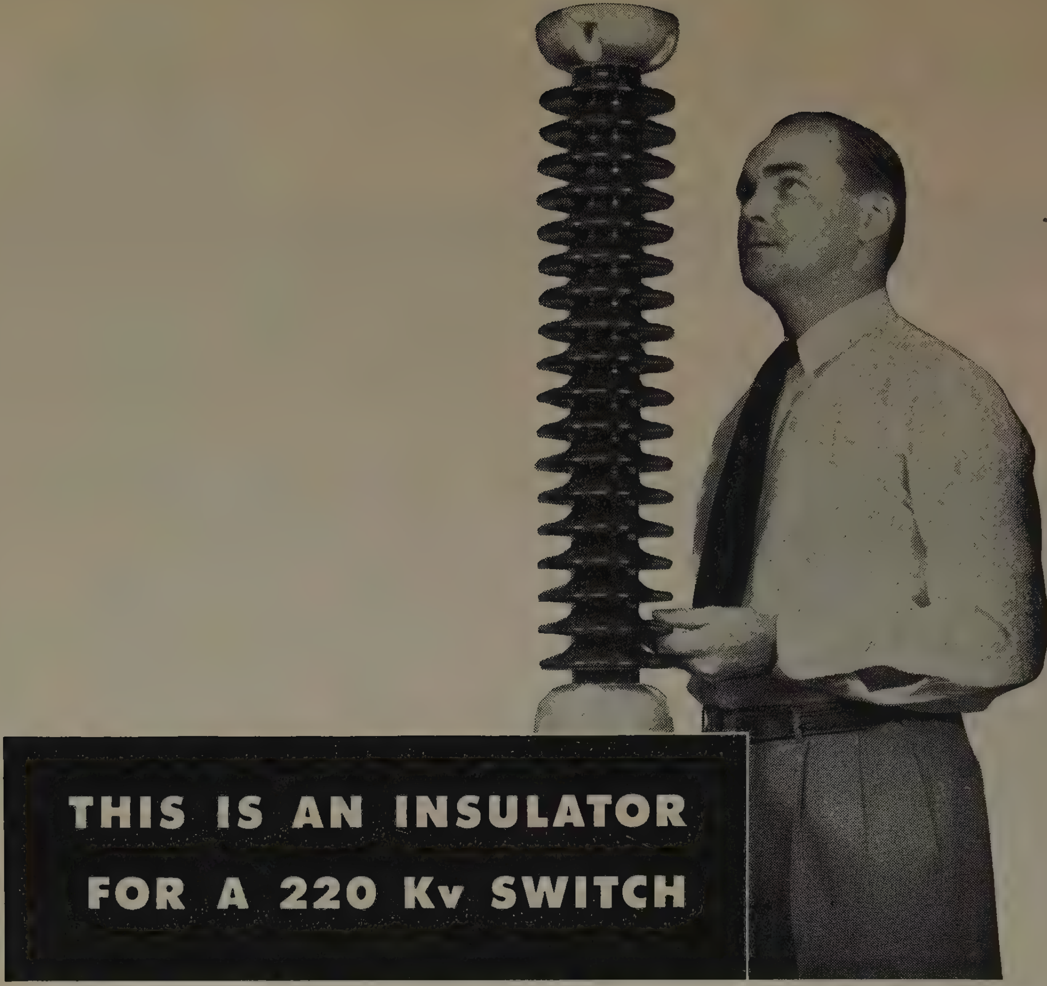
THIS IS ONE of the Chicago Pneumatic test racks. Drills are tested for speed, accuracy, temperature rise and electrical soundness. Every drill goes through this factory test.

AMERICAN STEEL & WIRE DIVISION
USS
AMERICAN ELECTRICAL WIRE AND CABLE
UNITED STATES STEEL

A STANDARD Cable for

- paper & varnished cambric cables
- asbestos cords and cables
- aerial, underground & submarine cables
- shovel & dredge cables

U·S·S AMERICAN ELECTRICAL



This porcelain is 31⅛″ long, 6″ in diameter over the petticoats, and has a solid core. We supply it to the switch manufacturer with caps assembled as shown in the photograph.

The switch manufacturer uses it as an insulating and load-bearing member. Nine such units are used for each tripod assembly (which is three units high) as a switch post for duty at 220 kv. Used now for nearly 15 years, these insulators have given practically perfect service.

A simple porcelain piece, you might say. Long, but not impossibly long. Solid, which means that electrical duty is not serious. Before firing, they are fragile and must be handled carefully—but many porcelain pieces are in the same category.

Their apparent simplicity is deceptive, as any ceramic manufacturer would find when he undertook to make them. We know it took all our skill and ingenuity to get them on a routinely dependable production schedule.

They are produced by lathe-turning from a solid "rod." Long and "skinny," there is a strong tendency to warp in drying. Then, holding and driving in a lathe of such a piece (41½″ long, 7¾″ diameter) without breaking, is quite a trick. Handling and kiln loading must be very careful. And, finally, after the piece is fired, there is no easy way to prove that there are no internal defects which may lead to mechanical failure. You see, in most pieces of porcelain, electrical testing is the certain way to detect mechanical flaws, but on such a solid piece there is no satisfactory way to impose electrical load for this purpose.

To provide sure protection against internal flaws in solid pieces of this type, we invested more than $10,000 in a special instrument which effectively identifies any internal flaws which can affect the strength of the piece. If you'll keep reading this series of ads, we'll promise to devote one of them to telling you about that machine in the near future.

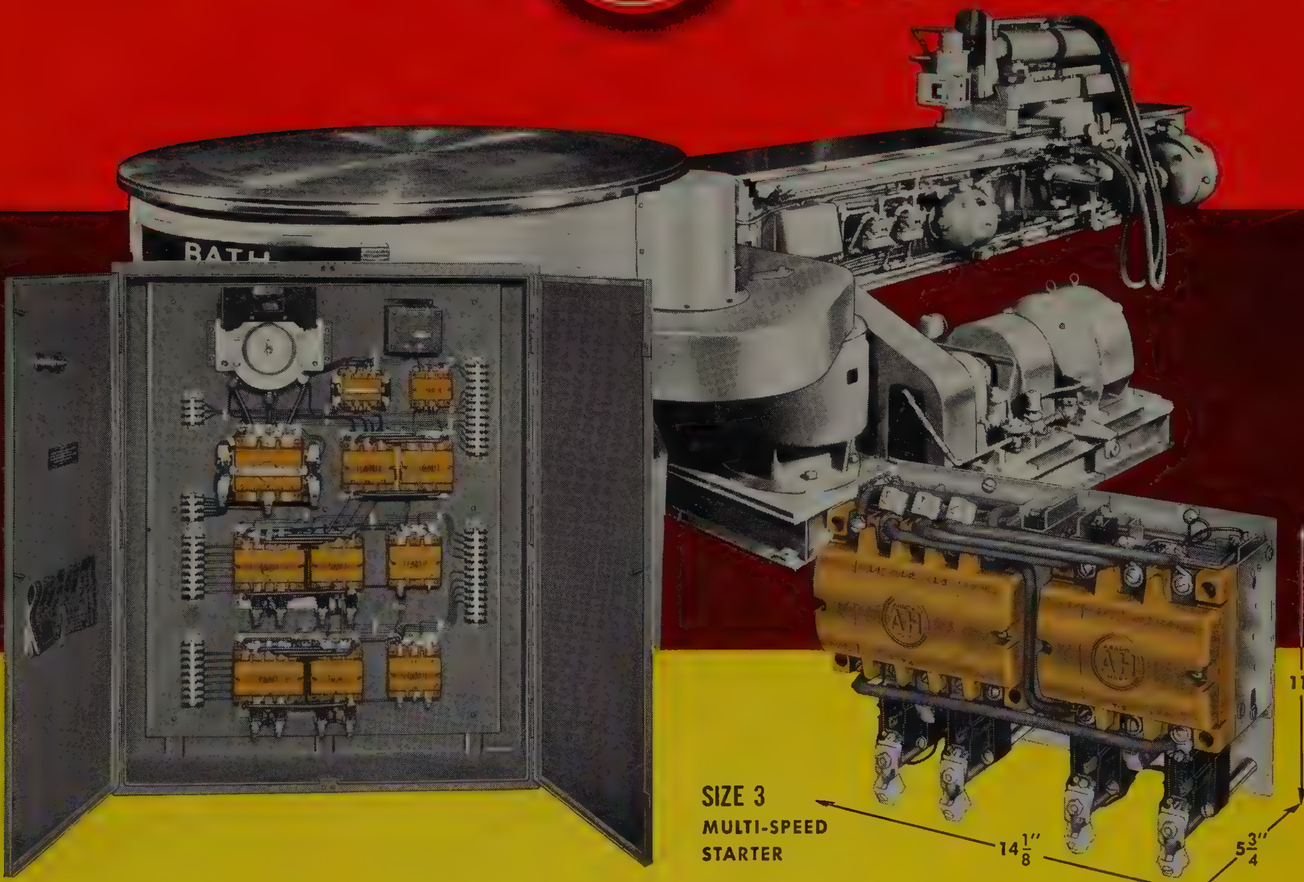
Lapp Insulator Co., Inc., Le Roy, N. Y.

Lapp

ELECTRIC EQUIPMENT DEMANDS MODERN CONTROLS FOR MAXIMUM PERFORMANCE

TYPE "RA" MAGNETIC STARTERS

ARROW AH HART



COMPACT DEPENDABLE OUTSTANDINGLY DIFFERENT

More motor control performance in less space is a must on this 150-ton metal contour former. Manufactured by the Cyril Bath Company, of Cleveland, O., the machine cold-forms a variety of precision tolerance parts in one operation. Controls must be convenient and dependable, to pace the high production output.

The job of designing and building control panels for this versatile line was awarded to Electric Control Products Co., also of Cleveland. Arrow-Hart advanced design "RA" Starters and Contactors were selected to meet all requirements. Just half the size and weight of conventional controls . . . more efficient and reliable, A-H motor controls made this compact installation possible.

Mounted in the panel without crowding are two Size 2 Contactors, two Size 2 Multi-Speed Starters (reconnected winding types), one Size 0 Contactor, one Size 2 Reversing Starter, one Size 3 Magnetic Starter, one Size 1 Magnetic Starter, and one 200-Amp. Type "N" Disconnect Switch — all in a panel 36" wide, 44" high and 10" deep. Ample room is left over for the neat, easily traced straight-thru wiring.

A complete line is available — starter sizes 0 through 4; NEMA enclosures for almost all atmospheric conditions; and a full line of push buttons and other pilot devices.

MORE ADVANTAGES IN TYPE "RA" (Right Angle) THAN IN ANY OTHER MOTOR CONTROL NOW ON THE MARKET

- *Exclusive "RA" operating mechanism.*
- *Just 1/2 the size and weight of conventional types — plus added dependability.*
- *Straight-thru wiring — another exclusive in-built feature. Safer . . . easier to install and maintain.*
- *Superior overload protection — with bi-metallic snap-action relays.*
- *Rugged contacts — positively aligned by full length guided travel.*
- *Complete arc suppression.*

BUY WITH CONFIDENCE

ARROW AH HART

THE ARROW-HART & HEGEMAN ELECTRIC CO., HARTFORD 6, CONN., U.S.A.

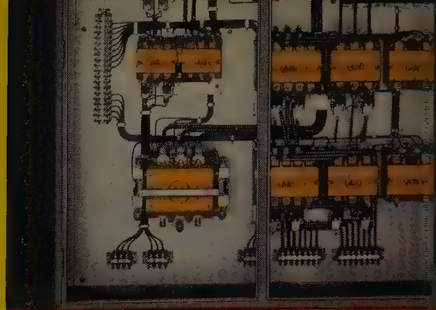
PROFIT BY PERFORMANCE

FOR EVERY APPLICATION

THERE IS AN AH MOTOR CONTROL

TO DO THE JOB AND DO IT BETTER

for example

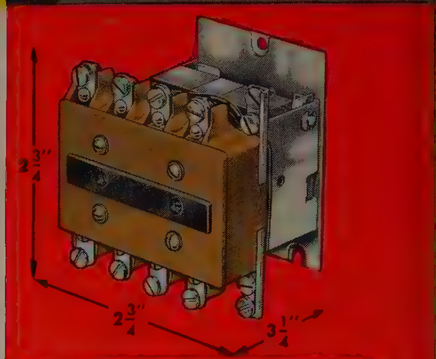


SIZE 00 TYPE "CRA" CONTACTOR

INCHES SMALLER AND EVERY INCH A CHAMPION

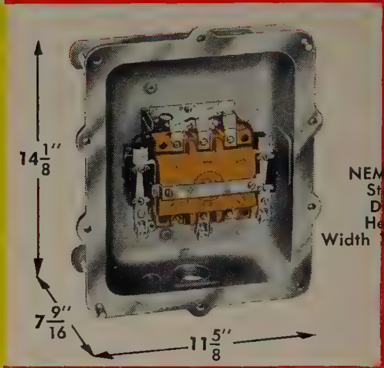
Incorporating a special adaptation of the revolutionary "Right Angle Design" Operating Mechanism, the "CRA" Size 00 Contactor offers all the plus performance inherent in this advanced design — and reduces conventional contactor size by as much as 3/4. Versatility is an outstanding feature.

The 00 is quickly and easily adapted from 4- to 8-circuit capacity; contacts can instantly be converted from Normally Open to Normally Closed. Construction is simple and rugged with only 4 basic sections. All wiring is in line and straight-thru.



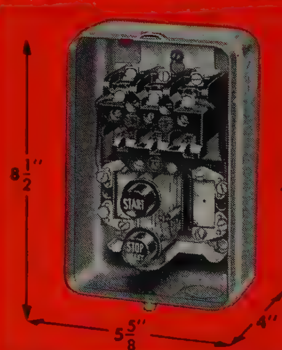
EXPLO-SAFE EXPLOSION AND WEATHERPROOF MAGNETIC MOTOR STARTERS

The Arrow-Hart EXPLO-SAFE Line brings to hazardous and exposed locations the "RA" advantages of added performance combined with great savings in space and weight. Despite the heavy, rugged construction of the corrosion-resistant cast Feraloy enclosures, EXPLO-SAFE Controls are just 2/3 the size and weight of conventional types — and there is generous space within the housing for easy wiring. NEMA Types IV (Weatherproof), VII (Explosive Gas) and IX (Explosive Dust) are available. Starters are supplied in Sizes 0 through 4, Contactors in Sizes 00 through 4.



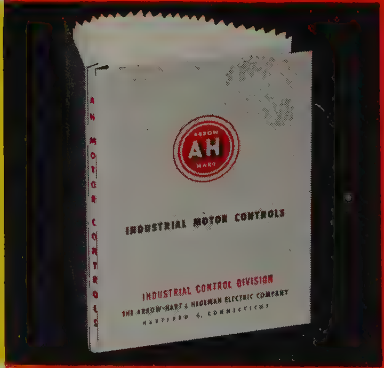
TYPE "RT" MANUAL STARTERS

Arrow-Hart Manual Motor Starters provide an inexpensive, compact and dependable means of stopping and starting single or polyphase motors rated up to 7-1/2 H.P., 600 volts. A variety of types, ratings and models with or without overload protection are available to fill practically every installation requirement in this power range. Both push button and toggle types are supplied for 1, 2, 3 or 4 pole use. Mounting may be flush or surface. Enclosures include General Purpose, Weatherproof, Explosionproof and Dustproof. All are designed and manufactured for fast installation, easy maintenance and long, dependable service.



GET THE COMPLETE STORY ON ARROW-HART MOTOR CONTROL. Send *today* for your copy of the new A-H Catalog, INDUSTRIAL MOTOR CONTROLS.

Just fill in and mail the attached coupon.



ARROW·HART INDUSTRIAL CONTROL DIVISION
HARTFORD 6, CONN., U.S.A.

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 HAWTHORN STREET, HARTFORD 6, CONN.

Please send my copy of the new catalog, INDUSTRIAL MOTOR CONTROLS.

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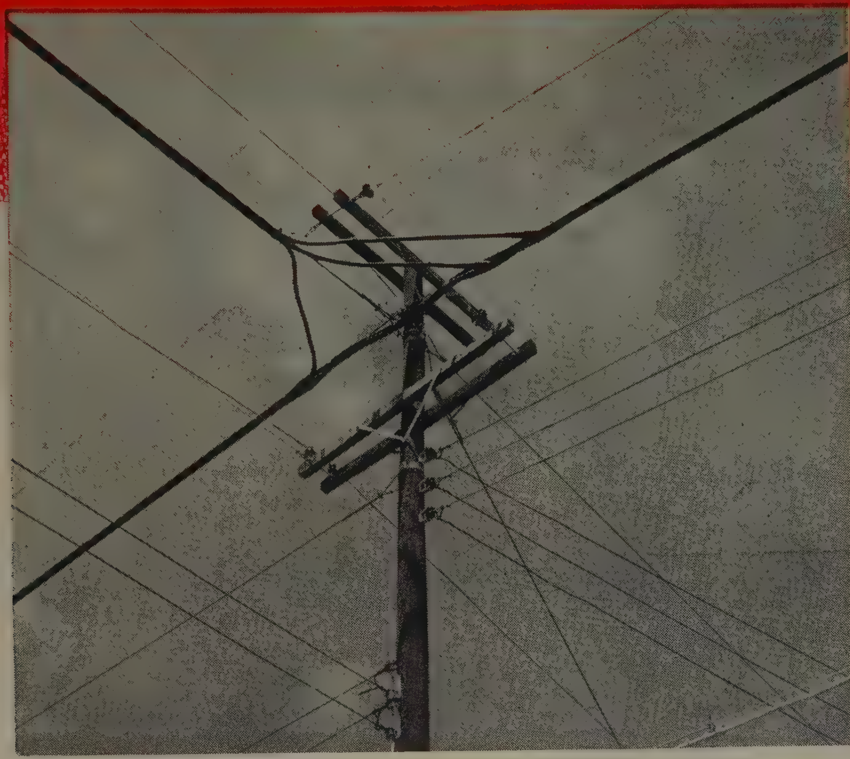
DO YOUR OVERHEAD LINES LOOK LIKE THIS?



This photograph shows many of the reasons why you should consider installing aerial cable instead of line wire. Notice what a neat, compact job the linemen have done and how unobtrusively the cable fits into the picture. Wouldn't you like your overhead lines to look like this?

It is a safe job too because the cable is completely insulated. Even if the cable should fall, which is highly unlikely, there is little or no danger to passers-by. Experience has shown that insulated aerial cable is the safest form of above ground transmission. Wouldn't you like that?

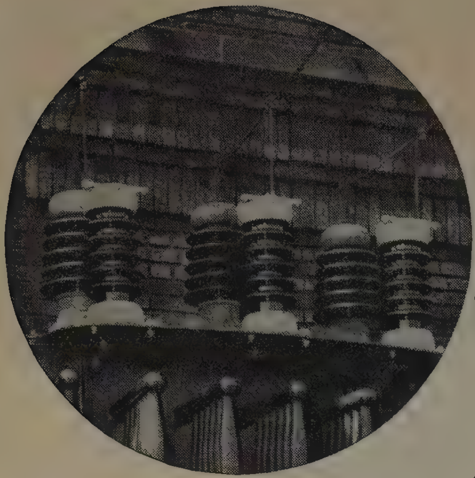
Notice how flexible the installation is too. See what a good looking "Y" tap has been taken off and notice the streamlined appearance of the splices. There is little danger here from swinging arcs or grounds caused by wet conditions. This type of an installation will reduce your trouble calls from owners of television sets. Wouldn't you like to increase safety and cut down on customer complaints?

Insulated aerial cable leaves the pole in an uncluttered state. Wouldn't you like to leave the impression with your customers that you practice good housekeeping?

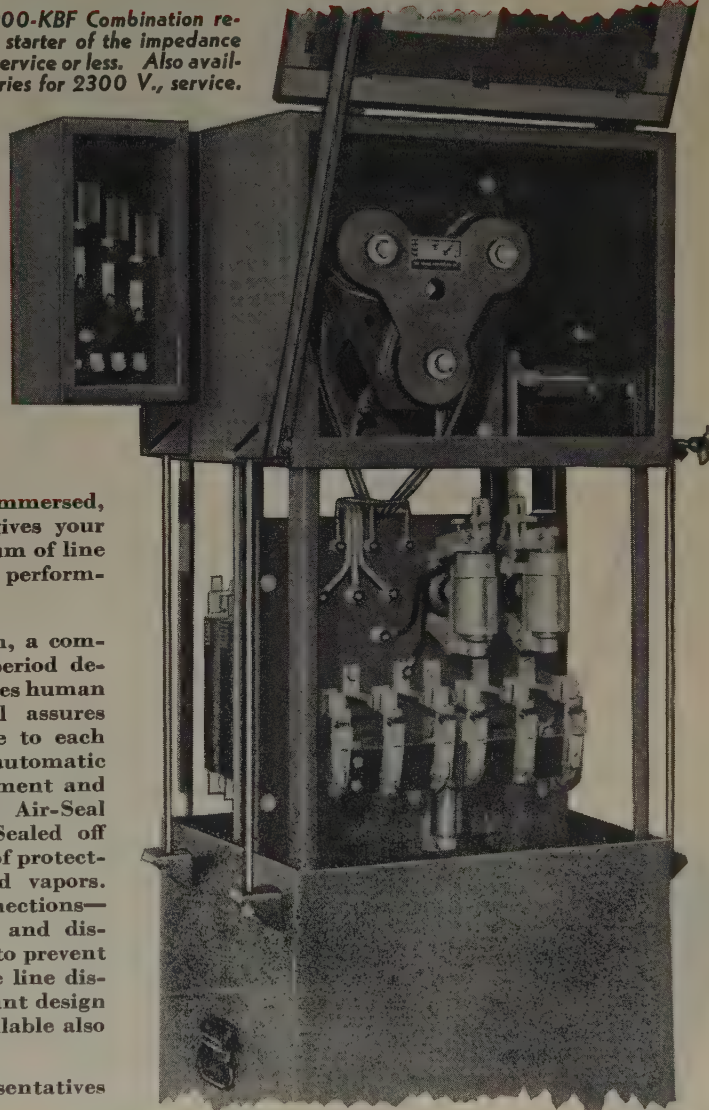
These advantages and more can be yours if you use Simplex Aerial Cables. You will find that they are exactly what you want. They are made in various styles and sizes to meet varying conditions. Want more information about these versatile distribution lines? A note to the address below will bring it to you without obligation.

Simplex - WIRES & CABLES

SIMPLEX WIRE & CABLE CO.
79 SIDNEY STREET,
CAMBRIDGE 39, MASS.,



Oil Immersed



Rowan Type 900-KBF Combination reduced voltage starter of the impedance type, 600 V., service or less. Also available in 950 series for 2300 V., service.

ROWAN
Type 900 Series
REDUCED VOLTAGE STARTER

Push button operated—fully automatic—this oil immersed, reduced voltage starter of the impedance type gives your induction motors a smo-o-oth start with a minimum of line disturbance. Check its design, construction, and performance features:

√ Closed transition type—utilizes for acceleration, a combination of current and time. √ Acceleration period dependent upon driven equipment and load—eliminates human element. √ Continuous wound impedance coil assures freedom from tap failures—impedance adjustable to each application. √ Magnetic overload relays with automatic reset—provides a combination of inverse time element and instantaneous operation. √ Rowan time-tested Air-Seal fuses—dependable short circuit protection. √ Sealed off centralized wiring compartment—eliminates need of protecting incoming and outgoing leads from oil and vapors. √ Provision for straight through conduit connections—facilitates installation and inspection. √ Tank and disconnect mechanism is mechanically interlocked —to prevent the lowering of the tank before disconnecting the line disconnect switch. √ Enclosure is of weather-resistant design to meet the requirements of NEMA Type X1—available also for Class I Group D locations.

Complete information available from Rowan representatives in principal cities of the United States.

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

TO HIT TARGET
from unstable decks of ship

A rolling, pitching ship... under attack from speedy, diving aircraft... counts on its anti-aircraft guns for protection... these guns must be able to stay on the target regardless of sea conditions. That's why the Ford Instrument Company was called on to design and build a control system that tracks and holds the target range with deadly accuracy.

This is typical of the problems that Ford has solved since 1915. For from the vast engineering and production facilities of the Ford Instrument Company, come the mechanical, hydraulic, electro-mechanical, magnetic and electronic instruments that bring us our "tomorrows" today. Control problems of both Industry and the Military are Ford specialties.

4

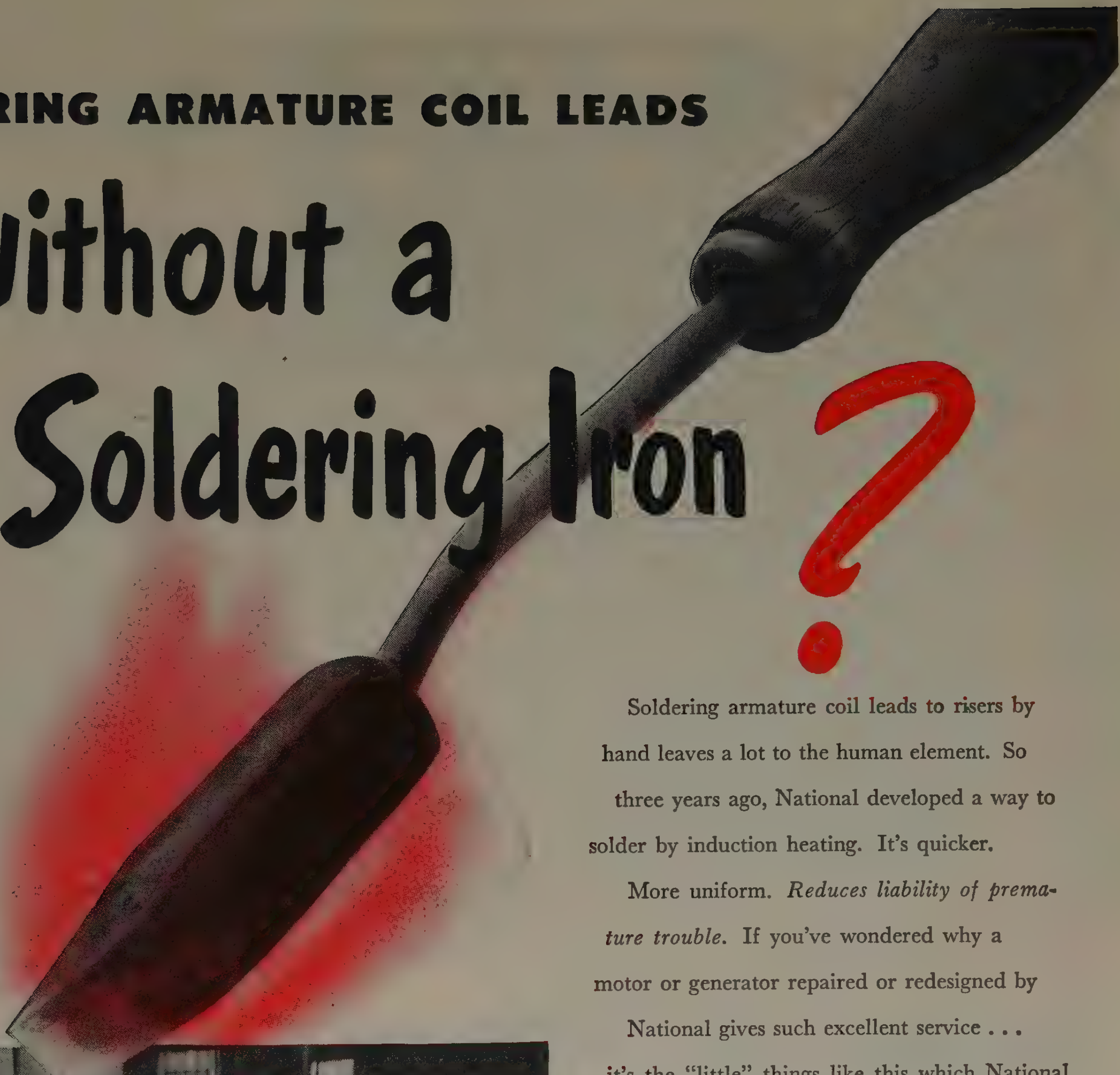
You can see why a job with Ford Instrument offers young engineers a challenge. If you can qualify, there may be a spot for you in automatic control development at Ford. Write for illustrated brochure.

FORD

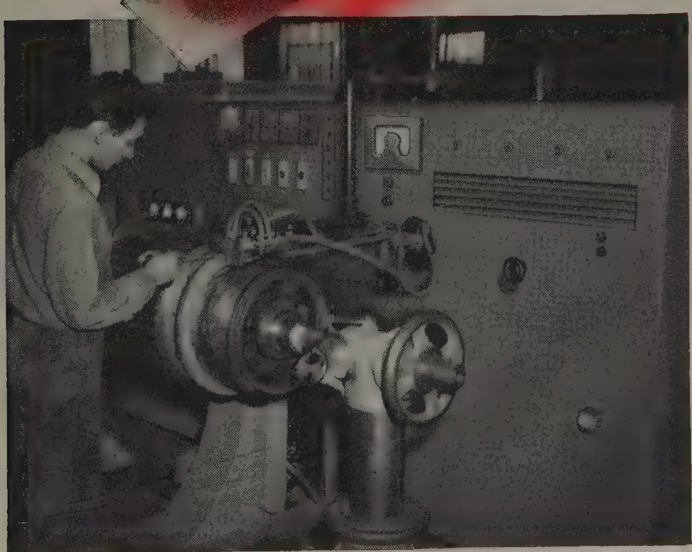
FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N. Y.

SOLDERING ARMATURE COIL LEADS

without a Soldering Iron?



Soldering armature coil leads to risers by hand leaves a lot to the human element. So three years ago, National developed a way to solder by induction heating. It's quicker. More uniform. *Reduces liability of premature trouble.* If you've wondered why a motor or generator repaired or redesigned by National gives such excellent service . . . it's the "little" things like this which National does, unheralded and unsung, that count so much. They mean a lot *in the long run.* Use National coils and engineering service for the unannounced advances which add so little to cost, so much to value.



Soldering armature coil leads to risers with National-designed induction heating equipment in the National plant.

Wherever you are our nearby Field Engineer is available

Visit us at Booth 1327, Plant Maintenance Show Cleveland, January 19–22.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A. TRADE MARK

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

Power Supply for Resistance Welding Machines

(April 1952)

AIEE Special Publication S-45 is a report of the AIEE Subcommittee on Power Supply for Resistance Welding Machines. Recognizing that the installation and use of any resistance welding process vitally concerns not only the industrialist requiring the process but also the welding machine manufacturer and the utility supplying the electric power as well, the committee has in this report brought together much pertinent data from the knowledge, literature, and experience in all these fields.

This publication supersedes the AIEE reports of the same title presented in 1940–1. The new work is required by developments in welding machines, new processes, better analysis of certain phenomena (such as measurement of instantaneous loads, and interference between welders), and a clearer understanding of the whole problem of power supply for resistance welders.

This report is not intended to be a complete solution of all welding problems, but should direct attention to the special electrical features involved so that a full analysis developed for a welding project can be readily understood and utilized by manager, master mechanic, and electrical engineer.

Copies are available for the price of $1.00 (no discounts permitted). Address:

Order Department
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street
New York 18, N. Y.

12-52

Gigantic Office Building Project Serviced by Ten Allis-Chalmers Network Transformers Is Part of Billion-Dollar Expansion Program

A NEW PITTSBURGH IS RISING out of the dust of demolition crews.

You can see its new face lifting out of the Golden Triangle — and it's an impressive sight. You see the Gateway Center (three of the eight office buildings now planned are completed), the towering Mellon-U. S. Steel Building, the aluminum-faced Alcoa Building, several downtown apartments, the Penn-Lincoln Parkway. And throughout the city thousands of new homes are going up in a booming residential expansion.

In this billion-dollar program, electric power will play a leading role. Allis-Chalmers is proud of its part in helping Duquesne Light Company serve a new, growing Pittsburgh.

Important components of the expanding distribution facilities are six 500-kva network transformers and four 750-kva network transformers installed to supply energy for lighting and elevators in the present three buildings of the Gateway Center. Each building has its own lighting and elevator transformer banks installed in vaults below street level. The underground transformer vaults are wisely designed for increased capacity when future load growth demands transformers of higher kva rating.

Completely Sealed Design Keeps Maintenance Low

Sealed design is one of the outstanding features of the Allis-Chalmers network transformers. All covers are welded on. That means the main cover gaskets and switch cover gaskets (and maintenance connected with them) are eliminated forever. Sealed design prevents leaks and breathing, thus helping to retard oil sludging and deterioration of insulation.

Other big features aside from the proved dependability of Allis-Chalmers transformers are: convenient unobstructed location of accessories; undercoating of base areas for added surface protection; transformer tank grit-blasted; and three coats of baked-on phenolic base paint which afford good water resistance.

Why not investigate Allis-Chalmers transformers for your network system? For more information contact your nearby Allis-Chalmers district office or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-3851

Any way you look at it...

SQUARE D's balanced* design means a better Motor Starter

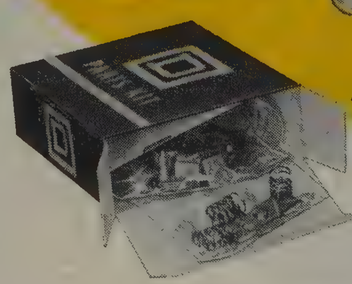
* Designed to provide the highest degree of accessibility, flexibility, and compactness—with no sacrifice of performance and long life.

EASY WIRING...
Plenty of wiring space and easy-to-get-at solderless terminals. Installation is a breeze.

ACCESSIBILITY...
Coils, contacts or overload relays can be changed without disturbing external connections. A screwdriver is the only tool you need.

FLEXIBILITY...
Three extra electrical interlocks may be added to size 1 starters; four to sizes 2 and 3. Contacts may be normally open, normally closed, or double circuit.

PERFORMANCE...
Straight line, guided motion minimizes wear. Large silver alloy contacts insure exceptionally long life and trouble-free performance.



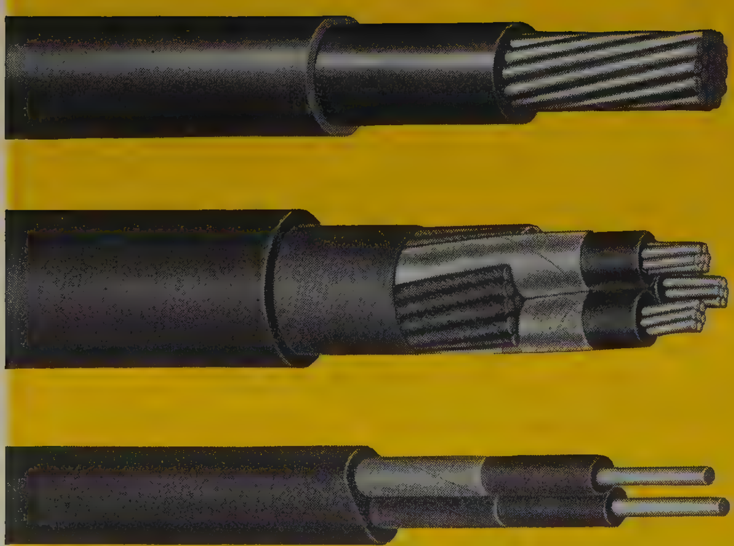
"Off-the-Shelf" Parts Kits make normal maintenance easier than ever. Each kit contains parts necessary to replace all load contacts and finger springs. Electrical interlocks also available in kit form.

***Write* for Bulletin 8536**
Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

SQUARE D COMPANY

Underwriters approved as Type USE—Style RR for 600 Volts. First to be approved by Civil Aeronautics Administration as Type A insulation for airport wiring under Specification L-824.



RECOMMENDED FOR

DIRECT EARTH BURIAL

OVERHEAD

IN CONDUIT

AT THE PUSH OF A BUTTON...

Once you zero-set a new Du Mont Type 304-A it is almost automatic to measure potentials of the waveforms on the screen of the cathode-ray tube. And you'll be surprised to find out how much more you know about your circuit; how much easier circuit development and production testing become when amplitude calibration is in front of you every time you examine a waveform. The new Du Mont Type 304-A will make your job easier, will greatly simplify measurements that formerly were difficult or inconvenient to make. The Type 304-A is not just another oscillograph; it is a true cathode-ray voltmeter, made possible by a precision calibrator and the tight-tolerance, flat-face Type 5ADP- Cathode-ray Tube. Only through the combined facilities, unique in the industry, of the Du Mont Cathode-ray Tube and Instrument Divisions could the Type 304-A Cathode-ray Oscillograph have evolved.

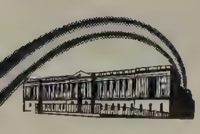
SPECIFICATIONS:

- Tight-tolerance, flat-face Type 5ADP- Cathode-ray Tube
- Vertical and horizontal amplifiers flat to d.c., 10% down at 100 KC
- Direct voltage measurement — Range, 0.1 to 1000 volts full scale, read directly from oscillograph scale; 5% overall accuracy
- High sensitivity — At full gain, 0.025 volts/inch
- Undistorted vertical and horizontal deflection more than 4 inches
- Expansion equivalent of 20 inches vertically and 30 inches horizontally with full positioning
- Driven and recurrent sweeps with sync limiting — Range, 2 to 30,000 cps; provision for extra-low frequency sweeps by externally connected capacitor; maximum writing rate, 1 inch/μsec
- Illuminated, numbered scale and suitable filter provided; scale illumination variable from zero to more than adequate for viewing and photography
- Improved stability of vertical amplifier

Price **$333.00**

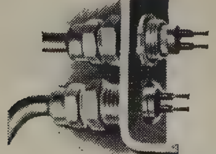
DU MONT INSTRUMENT DIVISION, ALLEN B. DU MONT LABORATORIES, INC., 1500 MAIN AVE., CLIFTON, N. J.

RESISTS HEAT



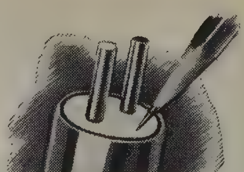
STS STRUCTURE IN INSTALLED!

e to age-deterioration its "all-mineral" con-n. Unaffected by high atures from current over-either accidently imposed eet emergency increased demands.



UNIT INSTALLATION!

No additional mechanical protection required. Safety m. i. Wiring is its own conduit. Available fittings permit installation in one operation using standard switch and junction boxes. Smaller diameter saves space, assures neat appearance.

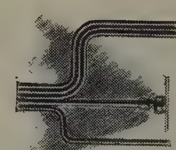


NO VAPOR PASSAGE!

Completely filled with compacted mineral insulation. No need for specially installed seals in the cable run to prevent the passage of gases through the wiring system. Safety m. I. Wiring is completely impervious.

COMPLETELY MOISTURE-PROOF!

Simple fittings are available to permanently seal both ends of each run of Safety m. I. Wiring. No possible entrance for moisture. Normal concern over this hazard is, thereby completely eliminated.



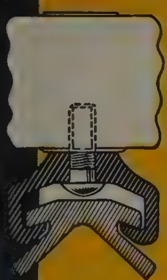
RIGID YET FLEXIBLE!

Thumb pressure bending, in ordinary sizes, easily fashions orderly wall patterns—conforms wiring to any contour. Once formed, and fastened with standard clamps or straps, Safety m. I. Wiring stays put.

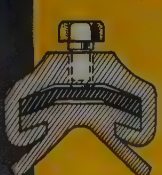
sively A General Cable Product

The Keystone INTEGRATED ALUMINUM* Conductor System

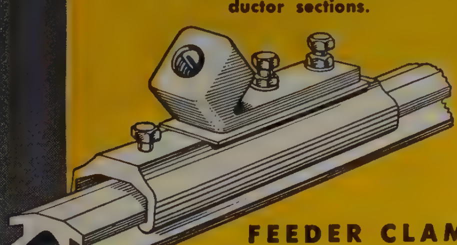
LOWER COST
LIGHTER WEIGHT, HIGHER EFFICIENCY
SAFER ENCLOSURES



HANGER SECTION
Conductor free to slide within support, allowing for expansion and contraction.



JOINT PLATE AND BOND ASSEMBLY
Non-loosening spring-type splice plate provides excellent electrical and mechanical joint characteristics between conductor sections.



FEEDER CLAMP ASSEMBLY
features a bimetal separator that eliminates galvanic corrosion between copper terminal and aluminum surface, providing foolproof, long-lasting connection.

An integrated power supply system designed to complement the best materials handling equipment—1000 amperes capacity for heavy duty systems . . . economical for use on control circuits.

The Keystone Aluminum Conductor System is now being employed in outstanding installations, after having been developed through years of research in the laboratory and industry. It has been carefully designed to solve the troublesome problems formerly encountered.

The light weight of this conductor system reduces costs of installation, insulators and supporting structures. Its non-corrosive qualities permit use on sensitive control circuits. Longer contact life. Compact design saves space, permits better protection. All components are pre-fabricated. Available complete with brackets and enclosures. No copper boosters nor priorities needed. Easily engineered, installed and maintained.

*Domestic and Foreign Patents Pending

Write today for new, illustrated 4-page folder on Keystone Integrated Aluminum Conductor System.

ELECTRIC SERVICE MANUFACTURING CO.
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In a career, just as in any journey, knowing when to make the right turn is of utmost importance. With 150 years of industrial leadership and achievement behind it, and a great expansion program ahead, Du Pont offers you an excellent opportunity for individual growth and technical achievement.

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STABILITY — 71 plants and 38 laboratories in 25 states;
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ADVANCEMENT — a living Du Pont tradition that has seen engineers attain the majority of top executive positions in the company;
SECURITY — a company benefits program, unique in industry for its comprehensive coverage.

Should you be interested in turning to Du Pont, please send complete resume, including educational qualifications to:

Mr. T. J. Donovan

E. I. du Pont de Nemours & Co., Inc.

Engineering Department 115
Wilmington, Delaware

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In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of these advertisements, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, non-profit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns.

Apply by letter addressed to the key number and mail to New York Office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

Men Available

ELEC ENGR, B.S.E.E., registered; 32, married; 5 yrs refinery plant engr-mtr control, telephones, instr ltg, distr. Desires pos as plant engr, maint, prod, project. Location, Midwest. E-685-480-Chicago

ELEC ENGR, B.S. in E.E.; expects M.S. June; 32, married, 1 child; 3 yrs des, devpmt elec controls magnetic amplifiers, servo-mechanisms. Desires pos des, research. Location, New England, eastern New York. E-686.

ELEC ENGR, B.S.E.E. Purdue Univ; 28, married; 1 yr training program diesel elec; 3 yrs indus selling elec motors and controls. Sales Mgr type. Location, Chicago or New York City. E-687.

Positions Available

ASSISTANT CHIEF ENGINEER, electrical or mechanical graduate, with at least ten years' aircraft control experience, to supervise a staff of engineers in design and development of electronic aircraft equipment. Salary, $10,000 a year and up. Location, Michigan. Y-7076.

CHIEF PRODUCT ENGINEER, electrical or mechanical, with ten years' experience in electronic computers, radar or fire control for electronic instrument manufacturer. Salary, $12,000–$15,000 a year. Location, East. Y-7198.

PRODUCT DEVELOPMENT ENGINEER, electrical or mechanical, to 40, with three years' experience in engineering and administration work in area of precision or intricate mechanisms. Should be creative thinker. Duties will include research and development to improve products. Both engineering and administrative duties for manufacturers of dental, electric and aircraft equipment. Company may negotiate placement fee. Salary, $15,000–$20,000 a year. Location, upstate New York. Y-7252-R-8989.

ASSISTANT PROFESSOR in electrical engineering, with at least a Bachelor's degree in the field of electrical power machinery. Salary, $3800 for nine months. Location, Virginia. Y-7351.

ELECTRICAL ENGINEER, maintenance, for work involving the supervision of men on maintenance and operation of high and low tension substation equipment. Some experience desirable. Salary, to start, about $5100 a year. Location, Ohio. Y-7358.

ASSOCIATE PROFESSOR with Master's degree in electrical engineering; Ph.D. desirable; will teach courses in instrumentation, servo-mechanisms, etc. Salary, $6000 for nine months. Should be qualified to teach graduate courses. Location, East. Y-7369(b).

SENIOR ELECTRONIC ENGINEER, 28–38, engineering degree, with five to ten years' laboratory and development experience in design and analysis of advanced electronic circuits in connection with the fields of radar systems, instrumentation, computers or communications. Should be able to apply fundamental principals of engineering and mathematics to the solution of original technical problems of more than average difficulty. Experience in managing or supervisory work an asset. Salary to $12,000 a year depending on experience, plus share in profits plus additional 25% for overtime. Location, New York, N. Y. Y-7390.

INSTRUCTOR in electrical engineering, to teach courses in electronics. Salary, from $3000 a year. Opportunity for additional compensation and/or graduate study. Location, New York, N. Y. Y-7403.

JUNIOR ENGINEER with B.S.E.E., electronic major preferred, with one or more years' experience in electronic testing, especially microwave testing; some relay or circuit experience, to test sub-assemblies and final systems; system performance checks on radar-like systems; must be able to evaluate performance characteristics. Salary, $3900–$4320 a year. Location, New York State. Y-7438.

DESIGNER, 40–50, electrical graduate, with at least ten years' small motor experience, to design subfractional hp motors. Salary, $10,000–$12,000 a year. Location, Connecticut. Y-7475.

ELECTRICAL PROJECT ENGINEER, electrical graduate, with five years' experience in automotive or aircraft electrical engineering. Knowledge of installation and testing of electrical units. Will assist in design and development of electrical harness and ignition systems on engines, devise test procedures and instrumentation for a manufacturer of engines. Salary, $5052–$6480 a year, plus $40.25 a month cost of living bonus. Location, Illinois. Y-7490(a).

SALES MANAGER, electrical engineering background, who has had some experience in the sale of circuits, relays, controls, etc., to radio and communications organizations. Must have administrative ability. Some travel. Salary open. Headquarters, Maryland. Y-7543(a).

JUNIOR ELECTRICAL ASSISTANT TO SUPERINTENDENT for work involving engineering studies of the municipally-owned electrical system, staking extensions and rebuilding and developing a set of map records for the water and sewerage systems. Starting salary, $3600 a year. Location, Georgia. Y-7581.

RESEARCH AND DEVELOPMENT EXECUTIVE to become head of engineering research department of electric motor manufacturer. Should be 35–45, graduate electrical or mechanical engineer. Company designs and builds special application, fractional hp motors. Salary open. Location, Ohio. Y-7602.

PATENT LAWYER for organization doing research and development in the field of underwater ordnance with specific interests in the fields of electronics, mechanics, acoustics, hydrodynamics and applied mathematics. Should have adequate background to enable him to search scientists' books for possible patentable ideas, be able to read scientific literature and have the legal knowledge to proceed with necessary steps to make application for patents. Will consider recent law graduate interested in qualifying to practice in patent cases. Salary, $5000 a year minimum. Location, Pennsylvania. Y-7653.

EDITOR, 35–45, electrical graduate, who has an inclination for writing. No previous experience necessary but must have experience in the application of motors and controls for industrial purposes. Salary, $8000–$9000 a year. Location, New York, N. Y. Y-7686.

ELECTRICAL ENGINEERS, men or women, with electrical engineering degree in communications or equivalent experience and a good general knowledge of electronics. (a) Project Engineer thoroughly familiar with the various applicable government specifications and have at least three years' experience as a technical writer on Government manuals. (b) Senior Engineer familiar with the book specifications of at least one Military branch of the Service and have at least one year's experience as a technical writer on Government manuals. (c) Junior Engineer. No writing experience required. Salaries, $4160–$7800 a year. Location, New York, N. Y. Y-7688.

QUALITY CONTROL ENGINEER for small plant making magnetic materials used in the electrical and electronic fields. Basic knowledge of physics and its commercial application essential, but quality control experience is a necessity. The quality control is a matter of precision in the process of mixing and pressing small orders to specifications. Salary, $5000–$6500 a year. Location, upstate New York. Y-7702.

MANAGER OF GOVERNMENT MANUALS with electrical engineering degree and two to five years' experience as a development engineer and five to ten years' experience as a writer of technical electronic manuals for the various armed forces. Should also have two to five years' experience in directing the activities of a group of writers on electronic equipment. Will be responsible for all of the company's instruction manual requirements on all contracts with government agencies, will supervise various technical writers and select outside vendors to perform instruction manual work, etc. Location, New York, N. Y. Y-7710.

ELECTRONICS RESEARCH ENGINEER for work on difficult research and development problems. Thorough academic background essential, for work in the following fields: computers, missiles, microwave equipment, and servomechanisms. Location, western New York State. Y-7740.

ASSOCIATE OR FULL PROFESSOR in electrical engineering, with Doctor of Philosophy or Doctor of Science degree in electrical engineering or engineering physics. Teaching experience and several years' of practical work in the engineering field in industry desirable. Applicant should be interested in pursuing research work and be able to assist in the development of a research program for the electrical engineering department. Teaching duties include courses in electronics and instrumentation to undergraduate and graduate electrical engineering students and will assist with the planning, installation and maintenance of laboratory equipment. Salary open. Location, East. Y-7745.

ELECTRICAL DESIGNER with at least ten years industrial transmission and distribution experience, to design and lay out power facilities for mining company. Salary, $7000–$8000 a year. Location, New York, N. Y. Y-7751.

ELECTRICAL ENGINEERS with fractional hp motor design experience, for nationally known manufacturer of motors, handling both commercial and government contracts. Will consider recent graduates at $3600–$3900 a year; higher for men with more experience. Location, Massachusetts. Y-7772.

INSTRUCTOR in electrical engineering, preferably interested in electronics, to teach course in electrical engineering. Salary, $3200–$4600 a year. Location, West. Y-7792.

METHODS ANALYST, electrical or mechanical degree or the equivalent, plus some knowledge of steel plate fabrication and welding practices. Salary, $4000–$6000 a year. Location, upstate New York. Y-7793.

TRANSMISSION SALES ENGINEER, electrical or mechanical, 35–40; with at least ten years' experience with utility transmission work. Will contact utilities on design, application and sale of high-voltage equipment; for a manufacturer. Travel 40% of time. Salary, $7200 a year. Employer will pay fee. Location, Wisconsin. T-9265.

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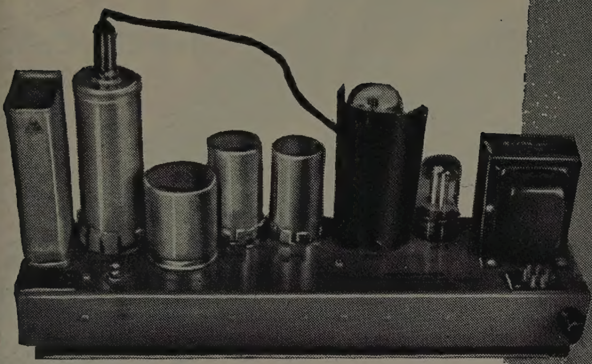

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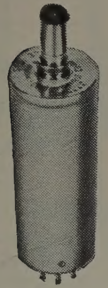

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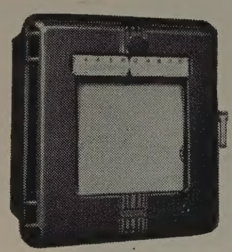

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